AGRICULTURAL ENGINEERING

Established 1920

This journal is owned, edited, and published monthly by the American Society of Agricultural Engineers.

Editorial and advertising departments at the executive office of the Society, Saint Joseph, Michigan. Publication office at Benton Harbor, Michigan.

RAYMOND OLNEY
Editor

RALPH A. PALMER
Associate Editor

SUBSCRIPTION PRICE: To non-members of the A.S.A.E., $3.00 a year in the U. S. and possessions and in Americo-Spanish countries, $3.50 a year in Canada, and $4.00 a year in all other countries; to A.S.A.E. members anywhere, $2.00 a year. Single copies (current), 30 cents each.

POST OFFICE ENTRY: Entered as second-class matter, October 28, 1933, at the post office at Benton Harbor, Michigan, under the Act of August 24, 1912. Additional entry at St. Joseph, Michigan. Acceptance for mailing at the special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized August 11, 1921.

CONTENTS FOR AUGUST 1940

Volume 21, Number 8

EDITORIALS

Publication Problems

BREVITY being not only the soul of wit, but the foundation of reader interest and publishing economy, we have been emphasizing it as means of making room in AGRICULTURAL ENGINEERING for more of the papers demanding publication.

By way of setting an example, starting with this issue and until further notice, we are eliminating the frontispiece and one of our editorial pages, thus contributing two out of three editorial pages to the cause of space for technical papers. These pages were particular pets of ours, and we sacrifice them reluctantly, but bow to the demand for this space for more important use.

Another step we propose to take is to abridge, condense, and otherwise limit Journal papers, so far as possible, to a maximum of four pages, and preferably less. To the best of our information, this is in line with the interests and desires of most of our readers. It conserves their time and provides space for publication of the important results, experiences, and viewpoints of more agricultural engineers. In fact, it is our observation that the papers which pack a real punch are often those of two pages or less. Where certain readers demand more information on one subject from one author than can be crowded into four Journal pages, it can be provided in some other manner.

As we see it, the most important function of AGRICULTURAL ENGINEERING is to record and report progress in the technology of this field, as revealed in meeting papers and other original manuscripts covering research results, methods, designs, application data, and experiences. The publishing job this journal must do is to convey, between agricultural engineers, their newest, best, and most important data, progress reports, ideas, viewpoints, and analyses of problems. Brevity of individual papers will help the Journal to do this job.

Editorial Functions

ONE secondary function of AGRICULTURAL ENGINEERING is to carry readers away, temporarily, from the rut of their immediate problems; to encourage that wandering and exercise of the technically disciplined imagination which begets new ideas, concepts, appreciations, solutions, understanding, inspiration, vision, and direction leading to professional development and valuable original contributions to progress.

To this end we have editorialized. We have had no key to ultimate truth. We have tried to avoid being dogmatic. Our editorial concern has been to stimulate thought, discussion, and imagination, rather than to dispense any all-important information. We have questioned this and that, like a city cousin on his first visit to the farm. We have philosophized amateurishly on interesting viewpoints and incidents. We have noted trends of thought and action.

In our editorial ramblings we have invited readers to review the past, orient various phases of the present, and scan with us the dim horizons of the future. We have tried to look at technical and professional problems in terms of fundamentals; to analyze and picture possible new technical approaches to agricultural engineering problems; to see the various phases of agricultural engineering in relation to each other, to other branches of engineering, and to various phases of agriculture; to examine fairly the apparent social and economic influences of agricultural engineering progress. In some cases we have hung by shreds of truth for the sake of argument which might bring to light additional truth. We have called attention to agricultural engineering problems, progress, accomplishments, viewpoints, and opportunities as we have seen them. Moreover, our editorial pages have been and will continue to be available as an open forum, within their limitations of space and function. Our editorial crusade, if any, has been and will be for more informed, profound, original thought by more agricultural engineers, as a basis for more effective work.

Such is the editorial job we will henceforth attempt in one page, rather than three. Possibly we can do it better in reduced space. We hope so. Then we can, with better grace, also ask our authors to remember that concise, difficult writing makes easy reading. And it is the readers of AGRICULTURAL ENGINEERING who must be served.

Propositions in Engineering Economics

WITHIN the past year or so we have noted some hopeful signs of engineering attention to significant quantitative relationships in economic matters. One of these is the address of Dr. William Trufant Foster on "Waiting for the Unborn Social Engineer." This is currently being given considerable distribution by American Engineering Council as a viewpoint for study and discussion, at the instigation of Leonard J. Fletcher (Past-President and Fellow, A.S.A.E.) in his capacity as chairman of the A.E.C. Committee on Engineering Economics.

Dr. Foster indicates, as a quantitative relationship, that effective buying power for consumer goods must at least equal the rate of production of such goods if production and prosperity are to be maintained. This suggests other expressions of quantitative relationships which might likewise prove significant. Consider the possible truth and implications of the following propositions:

Consumer satisfaction is a base value on which the volume of economic activity depends, and with which it varies in some determinable proportion.

Consumer satisfaction might be measured in terms of effective buying power for consumer goods.

Effective buying power for consumer goods is less than potential buying power by the amount of attempted savings from national income.

Wealth in natural resources and capital goods, which is the greater part of all wealth, can only amount to a fair capitalization of its present and expected rate of net contribution to consumer satisfaction.

The only part of national income which can be effectively saved is that proportion which needs to be and is reinvested to provide the total production capacity justified by the remaining volume of national income which becomes effective buying power for consumer goods.

We submit these propositions as further examples of aspects of economics influencing production and engineering; as the type of quantitative economic relationships which might favor understanding and action to promote a sound and less fluctuating material prosperity. We submit them also for consideration of their factual merit. If they can withstand critical scrutiny, they may help interpret some economic statistics and provide a guide to investment and production policies, and to the direction of engineering effort. We have the presumption to suggest them, not because we pretend to any profound knowledge of the subject, but because we believe that continued and widespread engineering thought along these lines can and will result in engineers increasing their contributions to economic and social progress.

AGRICULTURAL ENGINEERING

VOLUME 21 — AUGUST 1940 — NUMBER 8

Dairy Stable Ventilation

By A. M. Goodman

MEMBER A.S.A.E.

I WISH I knew where to direct you to find a perfect dairy stable ventilation system. The problems of stable ventilation include different weights and usually different numbers of cows, as well as different feeding and production. They include stables of widely differing construction and wall and ceiling insulation. These stables are variously located and have widely different exposures. Last, but not least, practically all of our stables are more or less exposed to *the weather*. We have to make the best of these conditions.

In New York State we have a stabling season that ranges from $5\frac{1}{2}$ to $7\frac{1}{2}$ months. We have winter temperatures that drop to zero in the southern end of the state and on Long Island, and often go to –30F or below in our northern counties.

We are recommending to New York dairy farmers a stable ventilation system that in several respects is different from others. This ventilation system consists of *one* outtake flue, for stables up to 200 ft long, and several inlet flues.

In barns up to 120 ft long the single outtake flue is located where it will be most out of the way in the stable and where it can go most directly from near the stable floor to above the highest part of the barn roof (Fig. 1). This outtake flue is well insulated all the way from the bottom to the very top. A top or head over this flue is not necessary.

The inlets deliver the incoming air close along the side walls and direct it straight upward.

What are the facts back of these recommendations?

Presented before the Farm Structures Division at the annual meeting of the American Society of Agricultural Engineers at State College, Pa., June 19, 1940. The author is extension professor of Agricultural Engineering, Cornell University.

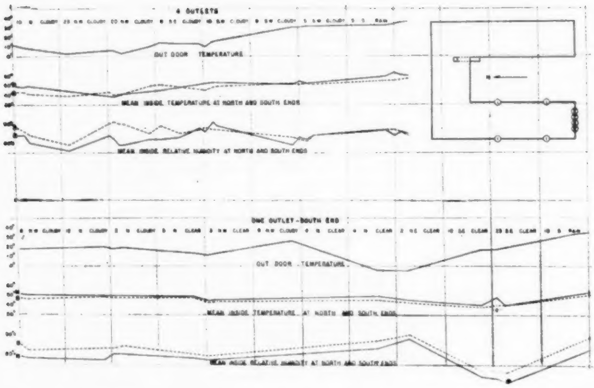
The late Professor F. L. Fairbanks and the author spent the winter months of several years studying the action of homemade and commercial stable ventilation systems in widely scattered sections of the state and in testing several systems that were more or less of our own design. By changing places at noon and at midnight, one or the other of us was always on the job at the barn. In these studies we observed and recorded the outdoor temperature, wind direction and velocity, barometric pressure, and condition of the weather. Within the stable we observed the ceiling and floor temperatures and relative humidity at numerous stations, made carbon dioxide determinations, measured the velocity of air in inlets and outlets, and traced the path of air currents through the stable. The simple, relatively inexpensive system which we recommend is based on these observations.

With this system as with any other it is assumed that one will not attempt to ventilate a stable that does not have side walls that provide thermal insulation, equal to at least that of two thicknesses of $\frac{7}{8}$-in matched lumber with building paper between them, and in which there are single glass windows in excess of 3 sq ft per cow. The volume of the stable to be ventilated should not, in our climate, exceed about 600 cu ft per cow, or 1,000-lb animal unit.

Probably the simplest way to consider this system will be to outline the observations that are back of the several features of this system. Let us start with the outtake flue.

The Floor Outtake. The temperature at both floor and ceiling at from 8 to 16 stations in the stables showed that the floor temperature may be expected to be from 2 to 8 deg lower than that at the ceiling. This lead us to believe that a ceiling outlet would permit the warmest air to escape and leave the stable cool, whereas a floor outtake, which would let only the cooler air near the floor escape, would

Fig. 1 (Left) Outtake flue on a long dairy stable. The stable extends into the leanto at the far end of the barn. The small flue near the corner of the main barn is on the bull barn. Fig. 2 (Inset) Inlet flues in stable with frame walls. Fig. 3 (Right) Inlets in a stable with heavy stone masonry walls. Entering air is directed straight upward. Tip windows are used only for summer ventilation



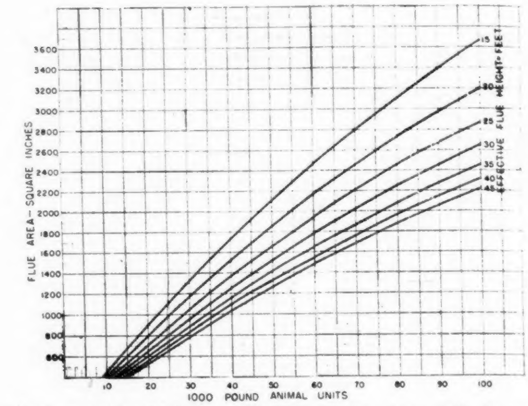


Fig. 4 (Left) Chart showing the relative effect of four outlets and one outlet in a stable 108 ft long. Diagram at the upper right shows arrangement of head or feed barn and the two stable wings; (1), (1), (1), (1) indicate the four outlets; (2), (2), (2), (2) indicate location of fans in second setup, with only one outlet point. Mean wind velocity and prevailing direction, as well as condition of the weather, are shown for each day. Fig. 5 (Right) Chart of outtake flue areas. Note that as the flues increase in cross section the rate of increase tends to diminish

not have such a marked effect on the stable temperature. We found this to be true.

We found that in the same stable, if we used ceiling outlets, when the temperature out of doors started to fall, the inside temperature fell at about the same rate. Whereas when a floor outlet was used a 40-deg drop in outdoor temperature caused only a 5 or 6-deg drop in stable temperature.

The Single Outtake. The relative humidity and carbon dioxide content of the air at floor and ceiling indicated that there is little if any difference in the composition of the air in various parts of the stable. This condition at first was puzzling because we knew that both water and carbon dioxide are thrown off in respiration and that they are discharged at the cow's nostrils.

Repeated observations of the path of NH_3Cl smoke liberated from a smoker, which Professor Fairbanks developed, showed clearly that the relative temperatures of the cows' bodies and the side walls causes very definite convection currents which thoroughly mix the air.

For some time we had tried to devise a way of reducing the cost of a stable ventilating system. The discovery of the fact that the stable air is in constant circulation and that it is continuously being mixed seemed to be an answer to prayer. We *theorized* that if a unit sample of air is continuously moving about the stable, why place several outlets in more or less inconvenient places when, if we wait a few moments, the unit sample will arrive at any point that we may select for its escape.

This theory was tested in a dairy stable that housed 56 milking cows. The stable is 38 ft wide and 108 ft long. Because they could be moved readily, four electric fans were used to exhaust the air from the stable. These fans were at first uniformly spaced with two on either side of the stable. They exhausted from near the floor. In these locations the fans ran constantly for two weeks and through a variety of weather. They were then relocated near the floor at one end of the stable and as close together as they could be installed, where they were operated for another two weeks. The air conditions within the stable indicated that the one point outlet was safe to recommend (Fig. 4).

Insulation of the Outtake Flue. Just what the thermal conductivity of the walls of the outtake flue may safely be we do not know. We find that walls of two thicknesses of matched ⅞-in lumber with good building paper between keep the temperature of the flue air well above the dew point. We measured the temperature of the air as it entered flues of this construction and again about 3 ft below where it escaped at the top and observed a drop of only two deg. We *do* know that it is important to insulate the outtake all the way to the point where the air escapes. Where this was not done, moisture condensed on the uninsulated section and ran back into the stable.

The Flue Top or Ventilator Head. No roof over the outtake flue is necessary. If one is desired it must have a level, well-insulated deck or ceiling supported by corner posts. The openings between these posts are clear. Experience has shown that a thin poorly insulated gable type covering over the flue causes eddy currents at the top of the flue, and that in very cold weather it will become ice covered as the result of condensation and freezing. As the weather moderates, this ice lets go and falls down the flue. The level, insulated ceiling effectively prevents both the condensation and the formation of eddy currents.

Size of the Outlet. For some time we used King's formula for flue sizes which reduced to its simplest form is $176xN/\sqrt{h} = A$, in which the constant, 176, includes a factor for friction and a 20-deg temperature difference between the air inside and outside of the flue; N is the number of cows, or 1,000-lb animal units; h the effective height in feet of the flue measured from the top of the inlets to the top of the outtake, and A the cross sectional area of the flue in square inches. More recently we recommend that the area of the flue be modified, so that the larger flues are not quite as large as the formula indicates (Fig. 5).

Inlets to Direct the Air Straight Upward. Some of the systems we studied had inlets that directed the incoming air horizontally. Tracing the air currents from such inlets with smoke showed that the result of being acted upon by gravity and by the force of the wind so influenced the course of the air that during the major part of the time it fell at an angle of about 45 deg and often upon the backs of the cows.

Air that is directed straight upward spills out of the inlet when not forced by the wind. When blown in, it strikes the ceiling where its velocity is checked and where it rolls around and mixes with the farm ceiling air before it joins the convection current and passes down along the wall. Introducing the cool air *(Continued on page 309)*

Farm Machinery Design — A Critical Appreciation of American Methods

By Wm. Vutz
MEMBER A.S.A.E.

AS AN American by choice, the vast reaches of American agricultural engineering have held a fascination for me that is inseparably bound up, from the first day, with the men whom I have come in contact.

In discussing design work—and I propose to do this as much by looking at the men responsible for this work as at the concrete results of their efforts—I am conscious of the important role that early impressions have played in shaping a growing mind which, from an early age, has had an inclination toward imagining and building things mechanical. I am conscious also that childhood impressions and adolescent experiences have been largely responsible for the approach of the mature mind toward present-day design problems. Two of these impressions I want to mention here. The first one is a threshing scene that is remarkable to me for the steady, even hum those broad wooden threshers would emit. This pleasant hum would only occasionally drop in pitch and rise in intensity, somewhat like a subdued roar, when a bundle was unevenly fed to the cylinder, accompanied always by the softer or harder sound of the steam engine exhaust as the throttle opened or closed. Lately, among the rattle of some of our present power-take-off-driven machines, this steady and purely functional sound of the old machines often comes to my mind.

The other picture dates around 1910, when my uncle bought an American binder. In the intricacy of its mechanism, and more so in the shape of certain parts, especially the castings, there was a strange note of things approached differently. I could only sense the silent tribute my uncle was paying to a foreign industry by buying an American machine when there were some domestic makes on the market.

AMERICAN READINESS TO SOLVE NEW DESIGN PROBLEMS

A curious echo to these early impressions came last December. Driving to Chicago, we passed many groups of Ever-Normal Granary bins. At a session of the Farm Structures Division, some of the manufacturers of such bins told us how in three or four months time they had rushed delivery of 40,000 bins to the government. Impressed as was everyone in the room by the organizing skill and the driving energy of the men responsible for the completion of this program, a different note was struck in the discussion when someone—admitting the momentary urgency of the program—questioned the wisdom and intrinsic value of these sheet metal additions to the American farm scene. I had the feeling that this gentleman touched on more basic things than needs of the moment when he expressed the thought that, in a stable agriculture, functionally correct farm buildings should rather be looked at from the longer term view, which would imply greater permanency, solidity, and individualization. There is no doubt in my mind that something more than purely utilitarian values attach to a well-planned set of farm buildings.

I should not like to see these last remarks construed as a reflection on the engineering skill or the sound judgment of the men responsible for metal bins and sheet metal structures, but the observation serves to bring out some rather significant points.

A first and minor one is merely a reference to the well-known readiness of the American engineering mind to attempt a solution to urgent problems, and to the speed and effectiveness with which its administrative skill can effect a solution if need be.

The second point has to do with the structural possibilities of sheet metal in farm buildings. I can hardly feel elated over the appearance of a round 2000-bushel grain bin, either singly or in a row, but I cannot get away from its practical advantages where storage space has to be provided quickly and from the fact that the metal container can provide eminently advantageous grain storage space. At the Chicago meeting some pictures were shown of larger units (which for that reason alone might fall into the class of more substantial and permanent buildings) ; units which, in their place, would form a respectable component of any set of farm buildings. I sense here an opportunity for the designers of such structures that is limited only by their engineering resourcefulness, their mastery of manufacturing methods, and an architectural ability bound up with familiarity with the farm scene.

DESIGN PROGRESS AIDED BY IMPROVED TOOLS AND MATERIALS

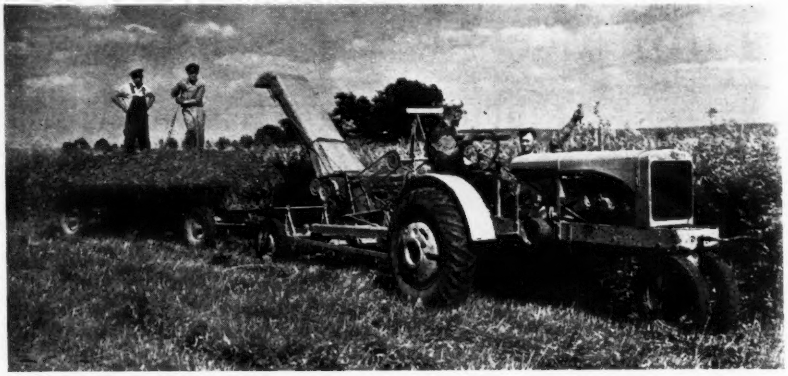
This parallel in the field of structures is brought up merely as a pertinent illustration of a process that has been going on for more than a decade in the farm machinery field.

Science and technology today provide the designer with more and better tools than theorists of a generation ago would have dreamed. We are well aware that the vast amount of precise factual information available is stimulating the increasing tendency toward more theoretical penetration of design. In contrast to those days when overgenerous proportioning lent an air of dependability to a machine part and to its manufacturer, we see parts made lighter and stressed higher today, and yet they are no less dependable than those of earlier vintage. The healthy influence of automotive practice is noticeable in the implement industry. While much is still being built in accepted implement ways, a look around any manufacturer's show floor will make clear what is meant by automotive influence. Hand in hand with better knowledge and application of materials goes an ever-widening resourcefulness in manufacturing and tooling methods. Here again much has been learned from the automobile industry.

The end of post-war prosperity, roughly about twelve years ago, marks the change. The depression brought calls for more flexible, more economical machinery; machines lighter, faster, and cheaper to operate. Many dreams of big

---

Presented before the Power and Machinery Division at the annual meeting of the American Society of Agricultural Engineers, at State College, Pa., June 19, 1940. The author is in the engineering department of New Idea, Inc.



A FORAGE HARVESTER DESIGNED TO INCREASE GRASS SILAGE ECONOMY FROM THE STANDPOINTS OF MOWING, CHOPPING, AND LOADING. IT IS A LOW-INVESTMENT MACHINE DESIGNED TO MEET THE FAMILY-FARM MARKET

units in machinery and land came to an end with the country's awakening to the advantages and social implications of small and medium-sized farms.

We are now confronted with attempts to express the awareness of this change in the machines offered to the farming public. I hope that none of my colleagues in design take the word "attempt" to imply a depreciation of their efforts. The word is used in the awareness of many machines and ideas presented which give a solution for a time but which are soon passed by newer and more practical conceptions.

With keener competition and shrinking markets, radical changes in machine design will continue, the cost of the product striking the dominant note in the endeavor.

Recognizing that few fundamentals underlying engineering have changed during the last fifteen years, let us take note of the tremendous influence that better knowledge of material, new materials, and fabricating methods have exerted on machine design. Compare sheet metal work on present small combines with that of 10 or 15 years ago; note the effect on durability and lightness and the vibration damping qualities that turret top or simpler methods of curved sheet construction afford. Compare this with older methods of angle-frame construction sheathed with square-cut flat sheets that emit a constant drone when the machine vibrates. Think of the reduction in noise where V-belts have replaced chains, or the savings in weight and overall width where they have taken the place of flat belt drives.

Many of us have taken such changes as a matter of course. It is a fact though, that V-belts and pressed steel sheaves were available long before they were used on combines; their advantages, I imagine, must have been apparent. Is it perhaps that a depression was required to awaken some of our designers to the possibilities of new materials?

We have another example of swift change in the adaptation of pneumatic tires to tractors and implements. I remember an evening about 8 years ago in Milwaukee, Wis., when some of our go-getting friends of the rubber industry and some visionaries from the tractor division of a large manufacturer there presented a great deal of interesting data. Openly some doubt was expressed by other men familiar with tractors; privately some of these men went much further than mere expressions of doubt. In the afterlight, I have a little more admiration for the visionaries who observed a situation, analyzed it, and stuck to their conclusions, than I have for the complacency of the doubters.

However, looking on rubber-tired implements and omitting those compromise cases where it is necessary to furnish a machine on either rubber or steel wheels, we may ask ourselves, Have the implement designers utilized the full effect and possibilities of pneumatic tires? We find cases of new design where full advantage of the cushioning effect of rubber evidently is not taken. Personally, I doubt whether many implement designers so far have bothered to think of the deflection rate of pneumatic tires when they framed their machines. While all these men know in a general way that their machines gain added shock protection from air tires, I question whether many of them have taken time to find out whether any and how much difference exists in the reaction of a tire to slowly applied loads and to impacts; in other words, just how far the cushioning effect really goes.

What I want to stress, in saying this, is the fact that many of our machine elements are dimensioned according to a guess that is conditioned, in most cases, by long experience and observation—a guess that is quite often right, but not always. If the guess is too low, the part is apt to give trouble in the field. The smaller one of two evils is a guess too high, with some material applied unnecessarily. Better and safer as this is than a part too weak, the goal in a highly competitive industry must be the possibility in between the two extremes, that is, the correctly proportioned part, safe with the minimum of material consistent with practical manufacturing methods.

As in other branches of engineering, there is an increasing realization that true design efficiency is to be attained only by combined application of theoretical principle and practical experience. Long years of experience will develop in man a familiarity with the materials he uses; such intuitive familiarity is apt to vary with the material and with the human medium. It is a comfortable feeling to any engineer if he can convince himself in cool figures that his first guess as to the proportions of a part were substantially correct. And occasionally, too, the figures will show that the guess was wrong. From my own experience I can state that relatively few parts failures in the field are due to incorrect analysis and erroneous basic assumptions, but that the great majority of them can be traced to omission of analytical check on loads and stresses. Conditions of load, speed, impact, etc., can as a rule, be pretty well synthetized in an attempt to determine their approximate magnitude.

We can point to some excellent test results and analysis of soil reactions on disks and on moldboard plows which have been published lately. Analysis should be the designer's passion. What I should like to see is more men capable of doing and actually enjoying something of the order of Col. O. B. Zimmerman's analysis of wheel stresses.

A successful engineer in another field, speaking of theory, once remarked to me: "As for that, I don't need to know it; I can hire enough men at $125 a month to do

that for me." Fortunately, this attitude is rare; emphatically, technological advances in the last 20 or 30 years require more complex knowledge in one single individual.

Remembering that any classification is a generalization and that in actuality lines are never drawn so sharp, let us take a look at the methods of approach generally employed in designing farm machinery.

METHODS OF FARM MACHINE DESIGN

First, we can build up a machine without much or any layout work. Very inadequately and reluctantly only, I call this the rule-of-thumb. Generally we find one man directing the work who has a pretty clear conception of what he wants to build, who has a lot of confidence that he can overcome any unforeseen difficulty, and who relies a good deal on his experience in the field, his familiarity with the subject, and a quality which we may call the "feel" of the material with which he works. This method is often used with experimental machines where utmost efficient design is not of primary importance, but where some principles of a functional nature have still to be established.

Following the second method, we can go to much detail in laying out a machine. This method is sometimes slow. It works to advantage only if we have a designing staff that combines manufacturing and field experience with plenty of theory and vision. In a fairly general way, this method is employed in the design of tractors.

The third method, a combination of the first and the second, is a practical short cut, often conditioned by the time allowed for a job and by the qualifications of the designing staff at hand. Many implements are developed that way. For the transition period to a mode of design aiming to include full theoretical penetration of the problem, this is a sensible approach. Most implement shops, I believe, are in this transition period. There are a few I know where the first steps are taken beyond that stage.

PRACTICAL DESIGN, VISION, AND TECHNICAL PROGRESS

It has been my good fortune to come in contact with many men of that group who like to think of themselves as practical men primarily, men who are out and out familiar with the farming picture and who master a high degree of knowledge of manufacturing methods. What strikes me as particularly noteworthy in this group is the enthusiasm the men usually apply to a job and the energy and speed with which they can push it to conclusion. Not long ago, one of these men asked my opinion on his solution to a problem of dynamic balance. To me the remarkable thing in his explanation was the fact that he put the story across to me in simple everyday language, where I, without further thinking, would have applied somewhat specialized processes of reasoning, a reasoning that would require transcription into the language of a salesman or a farmer. Another quality, outdated as it occasionally becomes, is that acquired capacity which I can only describe as the feel of and for material and shape. It is a quality that borders on the artistic and which has its source in the satisfaction these men derive from their work; much of it springs from longer association with the subject. Here precisely lies the danger that confronts these men and which only the most energetic of them can avoid altogether. The technology of materials is changing and expanding rapidly. In the use of all the possibilities that new and improved materials afford, the designing engineer is greatly assisted by a thorough theoretical training. He needs this as much as familiarity with farming, as much as familiarity with production, and also as much as enthusiasm for his work.

An enumeration of the ideal designer's qualifications reads like a list of generalities. The composite picture may actually be a little Utopian; nevertheless it should serve as a goal for our endeavors.

The designing engineer should be posted on research projects going on along lines that may have a bearing on work in his field. By research I mean what someone else has called the realm of discovery. By training and experience he should have the capacity to do much interpretation of discovery himself; that is, he should possess the necessary vision to sense and judge the importance of a new discovery to his field. We have some rather good recent examples in the rise of small tractors and small combines. It is clear that there were some men to start with who did a real piece of market research. I believe that most of the interpreting of the discovered facts was done by the men charged with the direction of design in the respective lines. If I have the picture right, there was no interpreting agency between market research and design; full credit for the development goes to the visionaries on that end.

A faculty to visualize a manufacturing process or the possibility of a process is only an elaboration on the more commonplace requirements that our man be practical and possess some vision.

Shop men generally are concerned with problems immediately before them; they think in terms of tools or improvements on tools for parts they are told to manufacture. It is the designers' part to scout the possibility of new processes that may bend his materials to the desired ends.

OPPORTUNITIES TO IMPROVE ENGINEERING TRAINING

Once more I come to use the expression "feel of the material." Admittedly this is a quality that depends much on the interest young men develop in the subject during training, and later on in the work itself, but I feel that some of our present engineering courses might be improved in that respect. Two examples will make clear what is meant. Discussing oil seals with a hopeful young sales representative not so long ago, we discovered that this man did not know the meaning of the universally used definition "cold-finished shafting." As much as on the young man, I think, a reflection falls on the men who had him under their wings more or less for four years of specialized training.

In the next case, let us suppose that the physical laboratory gives us the results of a simple beam test on mild steel and that we ask a young man to determine maximum unit stress attained in the test from cross section of the bar and deflection. Now if this man announces after a while that the stress was 150,000 lb per sq in, we can presume offhand that in his equation he used a load moment twice the actual magnitude. This in itself is a trifling mistake—we all make it at one time or another—but the more serious aspect of the incident is the fact that this man is not familiar enough with the properties of the material to arouse a suspicion in him that there may be a mistake in the calculations.

In closing, let me mention one gift which, next to the prerequisite of confidence in his own work, I wish on all young designers in the field, and that is a healthy amount of skepticism as to the success of their machines and ideas, at least until the results are shown on the employer's balance sheet.

Insect and Bacteria Control with Electric Light

VISIBLE light used to lure insects into various kinds of traps is as different from invisible shortwave ultraviolet radiation used to destroy bacteria, as ice differs from boiling water.

There has been a steadily increasing use of lamps in electric insect traps[1]. Perhaps next to their use in apple orchards to trap codling moths, the most rapidly increasing use is in corn fields to catch the European corn borer. Here the Mazda CX lamps have been found most useful. T. E. Hienton at Purdue University has carried on extensive research in that connection.

Mr. Hauser, at the Ohio Agricultural Experiment Station, tried out the theory that, since the tomato moth seldom flies in daylight, it might be possible to protect tomato fields at night by use of high-intensity artificial light. The brightest artificial source available, the 1000-watt, water-cooled mercury-arc lamp was set up in tomato fields at Marietta, Ohio, together with 3000 watts of tungsten filament lamps. All of this light failed to keep the moths away.

There is considerable evidence that light sources above 500 watts are not successful lures for insect traps. This is probably due to the glare confusing the insects or possibly due to the heat preventing them from flying into the trap.

BACTERIA CONTROL

In regard to the control of bacteria, there is increasing interest in the use of the hot-cathode type of germicial lamp reported last year. These lamps, emitting 95 per cent of their ultraviolet radiation at 2537A (Angstrom units) wavelength, are being experimented with for purposes of sterilizing various food products such as nuts, dried fruits, various fruit juices, cheese[2], potatoes, etc. There is no question as to the ability of this radiation to kill bacteria, mold spores, etc. The principal problem in their use seems to be one of application. Since their radiation has little penetrating ability, is reflected only by chromium and aluminum, and is screened out by thin films of grease, it is difficult to reach all surfaces of solids and necessitates the use of extremely thin films when applied to liquids. There seem to be better chances for the use of 2537A radiation in the field of killing air-borne bacteria, where the air around materials that are likely to be contaminated, is irradiated. The radiation provides an effective means of preventing contamination. For example, a can of maple syrup will keep almost indefinitely if it is not opened. Once it is opened, it is not long before it begins to mold on top. The mold spores must, therefore, enter through the air. If this air is irradiated, the mold spores are killed before settling on the syrup. Dairies and bakeries are using this method of keeping germs off the bottles during their transition from the washing machine to the bottling machine, and from bread and cake between the baking oven and the wrapping machine. Hospitals and schools are beginning to use ultraviolet barriers to prevent the spread of infection and even to sterilize wounds. Small ultraviolet hand lamps could probably be used to good advantage for treating the wounds of animals that would be difficult to treat with chemicals.

Another interesting use of light to control insects is the use of infrared lamps to destroy lice on animals, various plant insects, bed bugs, moths, etc. Dr. DeLong, at Ohio State University, carried on careful researches in this field. He concludes that infrared radiation from lamps will kill various pests, but that there is so little difference between the temperature necessary to destroy the insect and that which injures its host, that it is a rather difficult method of control to use.

INFRARED FOR FROST CONTROL

While frost is neither an insect nor a bacterium, nevertheless it is a pest and an attempt is being made to use light for its control.

Considerable interest and publicity has been given to an installation of 128 260-watt carbon filament lamps on 20x40-ft centers, 12 ft above the ground, in a lemon grove in West Covina, Calif. It is claimed that these lamps protected the trees from frost when the usual smudge pots and other methods failed. Protection was claimed to as low as 23F (degrees Fahrenheit). While this Committee does not have data either proving or disproving this claim, we do express the opinion that something other than the lamps was responsible for the protection of the trees in this grove. Roughly, this installation would produce approximately 0.1 Btu per cu ft of air around the trees per hour, which could not result in any appreciable rise in temperature.

The claim is made that carbon filament lamps burned under voltage kept the trees in an active growing state, thus making them more resistant to freezing. If such action were desired, high-efficiency, gas-filled, tungsten filament lamps would be more effective as the radiation from such lamps produces more photosynthesis than light from low-temperature sources.

A similar method of frost protection was tried by a large flower grower in Sanford, Florida, and proved a complete failure. So also were tests made in Columbus and Cleveland, Ohio.

The lighting research laboratories of the General Electric Company at Cleveland have recently developed a small attachment for the lightmeter, which enables this simple little device to be used for the measurement of shortwave ultraviolet radiation, previously a laboratory job requiring rather elaborate and relatively expensive equipment. This should greatly facilitate research work on the use of 2537-A radiation.

We look forward to steadily increasing progress in the control of disease and a lessening of losses due to spoilage by mold, etc., through the use of short-wave ultraviolet radiation.

B. D. Moses reports that (1) The Industrial Accident Commission (of California) has given approval to the use of light traps, (2) light traps have proven to be effective in the control of grape leaf hopper and grape leaf folder in California vineyards, and (3) a bulletin giving results of California research on grape leaf hopper experiments is in process of publication.

Presented before the Rural Electric Division at the annual meeting of the American Society of Agricultural Engineers at State College, Pa., June 18, 1940, as a progress report of the A.S.A.E. Committee on Electric Light for Insect and Bacteria Control— G. E. Henderson, B. D. Moses, C. C. Pink, and L. C. Porter (chairman).

[1]Light Reactions of Insects, C.R.E.A., October 30, 1939. W. J. Herms and J. K. Ellsworth, Univ. of Calif., Berkeley, Calif.

[2]Ultraviolet control of cheese mould. Report presented to the C.R.E.A., October, 1939. F. R. Smith, Univ. of Calif., Davis, Calif.

Transportation of Soil in Irrigation Furrows

By Colin A. Taylor

MEMBER A.S.A.E.

THE furrow method of irrigation is now in use on many hillside plantings where erosion under this and other current practices will cause destruction of the steeper parts of the land within the life of present orchards. It is occurring elsewhere at lesser rates, but wherever water is running downhill it carries with it the potential ability to transport soil. Furrows for use in irrigation are ordinarily made in loose cultivated soil, and loose soil is very easily picked up by water and transported along the furrow. When the soil is cultivated and loose, transporting velocities must be considered. These are relatively much lower than the eroding velocities which are ordinarily used in the design of irrigation canals. The intent of this paper is to assemble the available information on transportation velocities and discuss the soil movement factor in relation to the design of furrow shapes and choice of grades in irrigation developments.

The transportation of debris by running water has been investigated by Gilbert[1], who made an exhaustive study of the work of streams in transporting bed load. From the results of his laboratory work Gilbert developed certain formulas relating capacity for traction to slope, discharge, fineness of debris, and form ratio of channel. Slope was found to be the factor of greatest importance and discharge was second in order. The complex nature of the problem is aptly stated by Gilbert in concluding that "A valuable outcome is the knowledge that the output in tractional load is related to the controlling conditions (slope, discharge, fineness, and form ratio) in a highly complex manner, the law of control for each condition being qualified by all other conditions."

While Gilbert's paper deals with the work of rivers, his extensive laboratory experiments may be drawn on in a discussion of the transportation of debris in irrigation furrows. It so happens that the widths of channels used by Gilbert in the laboratory ranged from 8 in to 24 in and these widths have been employed recently in an improved method of furrow irrigation. Slopes used were from 3 per cent down to 0.5 per cent and less; discharges varied from 0.01 sec-ft up to 1.12 sec-ft; and fineness of debris ranged from that of a medium sand retained on a sieve of 60 meshes per inch up to particles with an average diameter of 0.28 in. The results, therefore, are directly applicable to the problem of transportation of soil in broad shallow irrigation furrows.

From an analytical study of his data, Gilbert derived certain expressions for the relation of capacity for load to the variables: slope, discharge, fineness, and form factor. The following symbols are used:

C, capacity for traction	F, fineness of aggregate**
S, slope	ϕ, competent fineness
σ, competent slope*	ρ, form ratio
Q, discharge	d, depth
κ, competent discharge	w, width of channel.

*For any particular discharge, degree of fineness, and width of channel there is a certain slope called "competent slope," below which there is no capacity for load. Above the competent slope capacity exists. This conception of competence is carried in the expression relating capacity to slope and similarly for discharge and fineness.

**Fineness is expressed as linear fineness or the number of particles in one foot when placed side by side.

The relationships are shown in the following expressions:

$$C \text{ varies as } (S-\sigma)^n$$
$$C \text{ varies as } (Q-\kappa)^o$$
$$C \text{ varies as } (F-\phi)^p$$

n, o, and p are variable exponents whose range for the experiments were:

n, 0.93 to 2.37
o, 0.81 to 1.24
p, 0.50 to 0.62.

Prepared especially for publication in AGRICULTURAL ENGINEERING. The author is assistant regional engineer (Region 10), Soil Conservation Service, U. S. Department of Agriculture.

[1]Gilbert, G. K. The Transportation of Debris by Running Water. Professional paper No. 86, U. S. Geological Survey. 1914.



FIG. 1 (LEFT) NARROW V-FURROWS AFTER AN IRRIGATION. NOTE THE PAVEMENT OF LARGER PARTICLES LEFT IN BOTTOMS OF FURROWS. NOTE ALSO HOW SIDES HAVE BEEN UNDERCUT AND THE BOTTOM WIDTH INCREASED. FIG. 2 (CENTER) BROAD SHALLOW FURROWS USED IN A FIELD IRRIGATION PRIOR TO PLANTING. FIG. 3 (RIGHT) BROAD SHALLOW FURROWS IN CONTOUR-PLANTED ORCHARD

FIG. 4 (INSET) UNIT FOR MAKING BROAD FURROWS. FIG. 5 (LEFT) CULTIVATING AND FURROWING IN ONE OPERATION. FIG. 6 (RIGHT) ORCHARD PLANTED ON HIGHLY ERODIBLE SOIL WITH THE FURROWS ON TOO STEEP A GRADE

The variations in n are related to changes in Q, F, and ρ; o, varies with changes in S, F, and ρ; and p varies with changes in S, Q, and ρ. Form ratio, defined as depth divided by width, is related to traction in such a way that for any given discharge on a given slope, capacity is at a maximum for a certain value of ρ. This value of ρ for maximum capacity varied from 0.5 to 0.04. For the range of the experiments, when mixed grades of debris were used, transportation was greater than when the particles were assorted and of nearly the same size.

From an inspection of the values for n, o, and p, it is apparent that capacity for traction is most sensitive to changes in slope, discharge is next in order, and that the effect of fineness is less than either of the other two. In applying the results of this investigation to the problem of controlling the movement of soil in furrows, it is obvious that slope along the furrow should be kept at a minimum. Also capacity for traction may be influenced by adjusting the form ratio so that the width is large in relation to depth. Control of fineness may be exercised to some extent by avoiding cultivation practices which tend toward excessive pulverizing of the soil. Furthermore, a pavement of the larger aggregate tends to form in the furrows during the first irrigation, and if the number of subsequent cultivations is reduced, fewer opportunities are permitted for water to come into contact with the finer particles of soil.

With the ordinary narrow V-type of furrow, trouble is often experienced from clogging and water breaking out of the furrow, particularly when the grade is flat or if there is much cross slope. Huberty and Brown[2] found that for contour furrows of the narrow V-type it was not advisable to reduce the grade along the furrow below one per cent. Steep cross slope and an irregular surface require more grade along the furrow.

By improving the shape of the furrow and making it relatively broad and shallow and smooth, it is possible to make a better water-conducting channel and reduce the trouble from clogging. Furthermore, the form ratio is improved and a greater discharge may be carried on a flatter slope with less transportation of debris. Figs. 1, 2, and 3 illustrate the two types of furrows.

The problem of cultivation tends to limit the width of furrow as difficulties are encountered when dirt must be moved laterally over considerable distances. With the Pomona type of furrower* (figs. 4 and 5) the free bottom width of furrow ranges from 12 to 24 in, the greater width being used where the land has the least cross slope. Where the cross slope (at right angles to the direction of the furrows) is steep, the bottom width is made 12 in. After the furrow shape has been smoothed and made of sufficient width so that clods or other obstructions will not clog the path of the water, there is little advantage in additional increase in bottom width where the land has a steep cross slope. The greatest advantage from improved form ratio is obtained when the cross slope to the furrow approaches zero. However, from the standpoint of disturbing the soil structure, it is desirable to use the widest furrow practicable as this tends to reduce the depth of cultivation required. When the minimum depth of cultivation is used, there is less loose soil available for transportation and velocities competent to transport loose soil are much less than those necessary to erode firm soil. This is another reason why it is desirable to use a shape of furrow such as in Fig. 3, one which requires the cultivation of a relatively shallow layer of soil and which will also maintain a reasonably good water-conducting channel for several irrigations.

In order to establish the most desirable grade for furrows on any given soil, it is necessary to know the velocities at which transportation begins for various sizes of aggregate. Gilbert's data are pertinent since they were obtained with conditions of slope, discharges, and widths of channel all of the same order as used in furrow irrigation. The tabulation (Table 1) of competent mean velocities at which transportation of various sizes of aggregate begins is assembled from Gilbert's work with three additional values from Login[3] as quoted by Gilbert.

The data in Table 1 together with a sieve analysis of the soil from any given field may be useful in establishing whether appreciable transportation of debris may be expected with proposed furrow grades. For example, if a sieve analysis shows very little aggregate larger than grade C and the velocity of water in the furrows is 1 foot per second, then continuous transportation may be expected. If a considerable proportion of the aggregate is larger than grade D, then a pavement of the larger sizes will form in the bottom of the furrows. After the pavement is formed

[2]Huberty, M. R., and Brown, J. B. Irrigation of Orchards by Contour Furrows. Calif. Agri. Ext. Service Cir. No. 16. 1932.

*Prior to July 1, 1939, development work on methods and equipment for making broad furrows was carried on by the author in the Division of Irrigation, Bureau of Agricultural Engineering, U. S. Department of Agriculture.

[3]Login, T. Royal Soc. Edinburgh Proc., vol. 3, p. 475. 1857.

TABLE 1. COMPETENT MEAN VELOCITIES AT WHICH TRANSPORTATION BEGINS FOR VARIOUS SIZES OF AGGREGATE

Grade of aggregate	A	B	C	D	E	F	G	H
Classed as	medium* sand			coarse sand			gravel, size of peas	
Sieve size, meshes per inch	50-60	40-50	30-40	20-30	10-20	6-8	4-6	3-4
Mean diameter of particles, in	0.012	0.015	0.020	0.031	0.067	0.12	0.19	0.28
Competent mean velocity at which transportation begins according to Gilbert, ft per sec	——	0.76	0.85	1.02	1.16 1.10	1.52	2.10 2.14	2.83
Competent mean velocity at which transportation begins according to Login, ft per sec	0.67	——	——	1.10	——	——	2.00	——
Average competent mean velocity at which transportation begins, ft per sec	0.67	0.76	0.85	1.06	1.14	1.52	2.08	2.83

*U. S. Bureau of Soils Classification.

there will be no further transportation until the soil is cultivated again and loose material of the finer grades is brought into contact with the water. Fig. 1 illustrates a pavement formed by the larger aggregate.

If there is sufficient clay in the soil, it tends to set and the furrows become "seasoned" in the same way as irrigation canals do in reaches where the banks contain considerable colloidal clay. According to the report of the Special Committee on Irrigation Hydraulics of the American Society of Civil Engineers[4], canals in alluvial silts, when colloidal, will withstand a velocity of 5.00 ft per sec when the water is transporting colloidal silts, and 3.75 ft per sec if the water is clear. The limit for a non-colloidal sandy loam is set at 1.75 ft per sec for clear water. If the grade along a furrow is such that considerable transportation takes place while the soil is loose, then considerable advantage is gained by using a type of furrow that may be left undisturbed for several irrigations so that the soil sets and becomes consolidated.

Some soils have neither the coarser aggregate which forms a pavement nor sufficient colloidal clay to develop a firm structure, and soils of this type are highly erosive and are not suited for furrow irrigation except possibly on very flat grades. An example of this type is shown in Fig. 6. In this case the orchard was laid out with furrows on too steep a grade and the remedy appears to be to abandon the furrows in favor of a portable sprinkling system.

Steepness of grade and size of aggregate are dominant factors in determining whether rilling develops. There are critical grades for various soil types above which water will not stay spread out in a thin sheet. Rilling develops and the water concentrates and cuts a channel until the bottom of the rill becomes paved with aggregate of a size too large to transport with the existing velocity.

Most orchards have been established with furrow grades so steep that a certain amount of transportation is inevitable, and this movement of debris cannot be eliminated as long as the soil is loosened by cultivation and the furrow method of irrigation used. The movement can be controlled if a vegetative cover may be used. An advantage gained by the use of broad furrows is that the cover becomes established in the bottoms of the furrows where it is very effective in retarding erosion. If it is desired to establish a permanent cover, then the furrows should be laid out so that there is little or no cross slope. Otherwise moles and other burrowing animals cause trouble and the water will break out of the furrows. It is also advisable to have a relatively steep slope along the furrows when a permanent cover is used in order that water may reach the lower ends of irrigation runs without excessive deep percolation losses near the source of supply. It is apparent from this that the irrigation plan for a field in permanent cover should be different than that for a field in which some cultivation is part of the soil-management plan.

Until recent years little consideration has been given to erosion under furrow irrigation. Corrections to existing conditions can be made in many ways and an improved design for the shape of furrows is a step toward this end.

[4]Fortier, Samuel and Scobey, Fred C. Permissible Canal Velocities. Transactions of the American Society of Civil Engineers, vol. 89, pages 940-984. 1926.

Dairy Stable Ventilation

(Continued from page 302)

at the walls stimulates the convection currents and helps to keep the stable temperature uniform. Figs. 2 and 3).

Inlets — Size and Number. Inlet flues 60 sq in in area have proved to be small enough so that, except in rare instances, they do not admit excessive amounts of cold air at one place, and large enough so that a relatively small number are needed. Two such inlets for each 7 cows, or 1,000-lb animal units, are necessary.

This system is simple and, as sometimes built, is crude. It has been criticized and ridiculed, but the fact remains that there are today hundreds of examples of this system in dairy stables in New York State, and it has been copied in other sections. For a recommendation, ask the man who owns one.

The Use of Fans in Ventilation. As suggested in the discussion of the outtake, electric fans may be used in place of an outtake flue. All other features of the system will be unchanged. Fans can usually be purchased and installed for less than an outtake flue can be built. On the other hand, fans require current for operation, and as time passes they require service. So long as the fan of proper capacity is in good condition it is satisfactory. When a fan is used, it is most desirable from the farmer's standpoint to have it arranged to remove the air from near the floor.

In deciding between an exhaust fan and an outtake flue for a stable ventilation system, it should be remembered that a ventilation system is to remove the products of respiration or *breathing* and that, since breathing is continuous, ventilation should be continuous. This means that the fan must run continuously for 5½ to 7½ months each year. This is a severe test for any mechanical device. It means that the fan must have a sturdy motor so enclosed as to protect its working parts from dust, moisture, and corrosive gases. It must have bearings that will not need attention during the stabling season.

We do not recommend thermostats for use with fans when installed as I have suggested. This is because, first, if the stable atmosphere is to be kept good the products of respiration which are produced continuously must be removed continuously, and, second, if the stable is properly built and well stocked and the air removed from near the floor, there is no occasion to stop the fan because of temperature.

Principles of Tile Drainage

By John R. Haswell
FELLOW A.S.A.E.

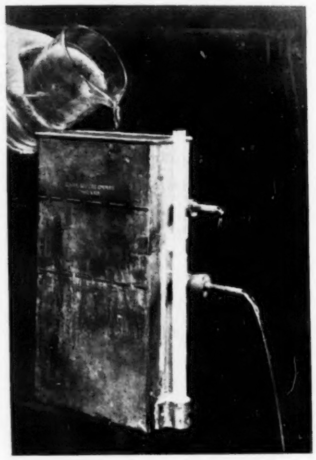
THIS paper deals with random drainage where each foot of tile is laid to secure maximum returns. Burying tile is not always draining land.

The installation of a uniform system of tile drains in a rule-of-thumb manner on rather flat, wet land, with some measure of success, is easy. Intercepting drains, a type of random drainage, even on slightly sloping land, are harder to install so that they will be effective. Here experience in tracing the seep water to its source is absolutely necessary, and all the possible surveys, pretty plans, and profiles will not go as far toward obtaining a successful system as close observation of strata and seepage when the ditches are being dug. Springs sometimes shift their location after being tiled.

It is useless to rehash what has already been written on the subject, and the accompanying bibliography gives many references covering points not touched upon in this short paper. The work of Mrs. Dorothy W. Graff[1]* is excellent for reference, while the publications noted in "Soils and Men"[2] primarily present the soil and water angle and do not necessarily cover phases of engineering. Many states, and also the U. S. Department of Agriculture, have publications especially intended for farmers[3,4] which should help in the practical installation of tile drains. Most of the information from the author's own experience relates to conditions in the more hilly East, and proper adjustments must be made for other situations. The work of laying out and installing tile is hard, yet the fascination of seeing a completed system run well repays one for his efforts.

While it may be trite to say "you have to tap the water where you find it," sometimes several years are required for tile to reach its maximum effect on the soil. It would therefore seem advisable for young engineers with limited experience to be certain that an adequate system of mains is provided, with as few outlets as possible, and to leave to the patient farmer the responsibility of catching all the springs and seeps with short spurs. This is far more economical than trying to dry an area to a point suitable for crop production in a few weeks. If the farmer is not willing to assume such responsibility, he is not tile-drain minded.

The little piece of laboratory equipment in the accompanying illustration, consisting of a tank of soil with a couple of perforated drain pipes across it at different depths, shows that the deeper tile in a uniform, fairly permeable soil, starts to run first when a rain has saturated the subsoil and raised the water table. It naturally runs a stronger stream and continues to discharge longer after a storm than the shallow tile. It is a good demonstration for getting farmers to place tile deeper. Some want only to get the tile below plow depth for safety and consider the drainage of surface water the only desideratum. Suck holes frequently ruin such tile drains.



DRAINAGE DEPTH DEMONSTRATOR

The ⅛-in copper tubes are 3 in apart, and the portions inside the tank have fine hack saw cuts part way through them on their under sides. They are inserted in ferrules in the side of the tank through rubber stoppers and the back ends are supported by thimbles soldered to the inside wall. The dashed lines were drawn on the tank to show the depths and extent of the tubes. The glass depth tube is unimportant

On the other hand, new drainage provided may be too deep in a tight soil, and as a result crops may drown before the ground water table rises like the action in the tank. A perched water table may develop that will make a tile drain operate although all the subsoil is not saturated. Differences in the soil strata also make variations. A mottled coloring shows a lack of air in the subsoil and the need for drainage.

Water enters tile at the under sides of the joints like leaks in a boat, and the channel formed by the tile conducts it away by a gravity flow to a lower point. Sometimes a pressure head exists. C. G. Elliott allowed for some pressure head from water in an open soil, considering it to increase the fall in the tile by half the drain depth. Where the tile has run out of catch basins receiving a heavy storm runoff with no surface relief, such as in large ponds, the author has sometimes taken the hydraulic grade as the ground surface, thus increasing the fall by the full depth of the tile. This, of course, is risky as it puts a pressure head on the tile which may make water seep out of the joints throughout the perimeter and produce "blowouts." When the pressure is relieved after the first rush of the storm has passed, there is a tendency for supersaturated earth to work into the tile. Both difficulties can be prevented by wrapping the joints with tar paper. This method of design permits the use of a smaller main, yet one large enough to discharge the storm water in ample time to prevent drowning the crop. If the soil water is removed in a reasonable time, no damage results. However, this would not work in muck soils late in the growing season. (See page 731, "Soils and Men".) Toxic solutions collect in the subsoil water and when they rise they damage the crops.

It used to be customary to run uniformly spaced drainage systems with the greatest fall possible. Now, as W. C. Krueger says relative to intercepting drains, "lines across the direction of the soil water movement" will catch the most seepage. However, they have practically no effect on the land above them. This is well illustrated by L. A. Jones[4].

The limiting factors considered in our drainage work in the East are in general:

1 Outlets. Ditches or streams that provide free flow, except possibly in freshets when the ends of tile drains may be covered for not more than 12 hours at a time during the growing season.

2 Minimum grade. With (Continued on page 316)

Presented before the Soil and Water Conservation Division at the annual meeting of the American Society of Agricultural Engineers, at State College, Pa., June 17, 1940. The author is professor and head of the department of agricultural engineering extension, the Pennsylvania State College.

*Superscript figures refer to the bibliography accompanying this paper.

Thirty Years of Supplemental Irrigation Studies

By W. L. Powers
MEMBER A.S.A.E.

THE study of supplemental irrigation on subhumid lands over a 30-year period leads to the conviction that light irrigation would be valuable drought insurance throughout much of the so-called humid and subhumid areas of the country. With average soil, two weeks of rainless summer weather may be considered a dry spell or droughty period. In a humid region planting often occurs with the ground water still in the subsoil. The change from moist spring to dry summer weather results in conditions difficult for plants to adjust themselves to. The bulk of the available plant food in humid soils is confined to the surface, or a horizon in which most of the feeding roots are found. Moisture is needed in this feeding zone to favor activity of good nutrient-supplying processes in the soil and to insure vigorous growth and high quality of produce.

In western Oregon we are practicing supplemental irrigation successfully where the annual rainfall is from 38 to 90 inches a year, because the normal Willamette Valley rainfall for the three summer months is under two inches. Experiments in this area were initiated on the assumption that, if it would pay to pump water a reasonable lift for ordinary field crops, it should certainly pay to apply gravity water where securable locally for more intensive horticultural crops. At the beginning of this study in 1907 only a few hundred acres were irrigated in the Willamette Valley, which is the major agricultural valley of western Oregon. At present about 40,000 acres are actually irrigated, and plans are under way which promise to increase this some tenfold.

ADVANTAGES OF SUPPLEMENTAL IRRIGATION

The advantages of supplemental irrigation for free-working, naturally drained subhumid soils are as follows:

1 It controls soil moisture and overcomes drought.

2 It provides green pasture and green feed late in summer.

3 It saves the clover stand and makes a cutting the first season.

4 It makes double cropping possible, such as late crops after early crops.

5 It aids the beneficial bacterial and chemical activities in the soil.

6 It improves quality and aids control of crop pests and diseases, especially of vegetables and berries.

7 It increases efficiency of soil moisture during the best growing weather.

8 It aids in deep or early fall plowing and intensive cropping.

9 It softens clods and dissolves plant food.

10 If properly planned where feasible, it pays in increased yields, net profits, and productive values. Supplemental irrigation under western Oregon conditions has usually decreased the unit cost of production.

The soils best suited for supplemental irrigation are those that are naturally drained and free working without being either too sticky or too coarse. A good supply of organic matter is desirable to facilitate the absorption and retention of moisture and prevent the soil from baking or cracking. The usable soil water capacity is perhaps the most important physical property of the soil from an irrigation standpoint.

Root zone studies show that most of the feeding roots of ordinary field crops in subhumid soils are in the surface two or three feet and that the greater part of the removal of moisture by plants occurs from this zone. Ladino clover and green beans are found to extract moisture mainly from the first two feet.

MARKETING MOISTURE IN CASH CROPS

The aim in supplemental irrigation should be to maintain usable moisture in most of the root zone until late in the growing season and then market it in cash crops. The object is to get the highest possible efficiency out of every acre-inch of water received or provided. This water should be measured and applied according to the water capacity of the root zone.

The crops found best for supplemental irrigation are the truck crops, certain small fruits, ladino clover pastures or seed crops, and the row crops that make maximum growth late in the season such as roots, potatoes, and corn. Potatoes and beans are cash crops giving large returns with a small amount of water and will carry a reasonable expense for proper irrigation. Clover seed yields may be substantially increased by one irrigation. The quality of vegetable crops may be strikingly improved and the yield usually is doubled.

The water supply for irrigation in a subhumid climate is generally of good quality. Its source may be a perennial stream or ground water developed by a driven well from a gravelly, substratum under river-bottom soils. In many states water rights must be established and are initiated by filing an application upon forms provided by the state engineer's office. The amount of water needed will vary with the soil, climate, crop conditions, or other factors. During dry summer weather in the Willamette Valley, the average requirement may be one-seventh of an inch per day.

OPERATING FACTORS

The water requirement per unit crop based on a 30-year study is on the order of 6 in per ton alfalfa or clover, 5 in per 10 bu of beans, 7 in per 100 bu potatoes, or 4 in per 10 bu of grain.

The farm irrigation pumping plant gives an independent source of supply of water where only a portion of the farm is irrigated for late-growing season crops. Overirrigation is improbable where every acre-foot represents an additional cash outlay. Where supplemental irrigation is of proven value, it is advisable to install an efficient pumping plant in the beginning. Great improvement has been made in pumping equipment during the last two decades.

The choice of crops for response from irrigation should be considered in relation to markets and the economic limit of pumping lift. Less levelling of land is permissible in a humid land due to raw subsoils. Much study has been given

---

Presented before the Institute of Irrigation Agriculture at Reno, Nevada, June 27, 1940. Approved by the Director as a technical paper contributed by the soils department of the Oregon Agricultural Experiment Station. First publication in AGRICULTURAL ENGINEERING. The author is a soil scientist of the Oregon Station.

the sprinkler distribution system which offers compensating features here. These factors all have a bearing on the question as to whether irrigation will pay.

If the cost of water is small in proportion to the amount of value of the increase, then irrigation should pay. Efficient use of water is necessary for irrigation to be successful under either droughty or even arid conditions. The economic limit of profitable lift will depend on the amount of lift, cost of energy, amount of water required, amount and value of the crop increase, and the skill and economy of the irrigator. Water lifted 25 ft has netted a profit of $1.50 for each acre-inch or dollar of total annual cost.

WATER SUPPLY INFLUENCES ON EQUIPMENT AND METHODS

Well development, if required, needs careful study. Inquiry should be made as to depth and yield of existing wells in the locality. For irrigation on a field scale, the well should encounter a large volume of water-bearing gravels related to the ground water. When in doubt, it is advisable to first run down a small well, keeping a log of the formations encountered and thickness of the water-bearing strata. The larger well can then be more intelligently and perhaps more economically planned and built. In a region where alkali is present or suspected or in the estuaries near the sea coast chemical tests as to the quality of the water may avoid disappointment.

Farm pumping plants should have capacity to serve the area to be irrigated during the height of the dry period. For flooding from 1 to 2 cu ft per sec is desirable. It is fundamental to remember that a cubic foot per second will amount to one inch depth on one acre in one hour, approximately. For furrow irrigation one-half cubic foot per second may serve a moderate area. For small water supplies of 50 to 200 gpm, a sprinkler may well be considered if crops of good cash value per acre can be grown. A supply of 5 gpm per acre is needed for sprinkler irrigation during the driest period.

The advantages and disadvantages of sprinkler distribution may well be considered in the distribution of pumped water to crops which return a good value per acre. The advantage of sprinklers include less leveling, less water used, less labor of attendance, ability to supply light, frequent irrigations to the top soil, aerated water or avoidance of any water logging of the soil and prompt freshening of grass after an application of liquid fertilizer. The disadvantages of sprinklers are the higher first cost, distribution interference by wind, higher power requirement due to pressure needed, need of clear, screened water to avoid clogging or corrosion, and the requirement for moving pipe or sprinklers at regular intervals.

SOIL AND CROP INFLUENCES ON WATER REQUIREMENTS

Except for early flood water supplies, water should be measured and applied according to the useful water capacity. Irrigation should be given when the moisture content falls and approaches the wilting point for the feeding root zone and in an amount that will raise the soil moisture content of this stratum to the excess point. Fine sand may hold only an inch of useful water per foot of depth, fine sandy loam $1\frac{1}{2}$ in, and silty clay loam 2 in, approximately. The irrigation efficiency studies indicate that green beans or ladino clover extract mainly from the first two feet of soil.

Irrigation efficiency studies have been made by means of large numbers of improvised rain cans and systematically sampling the soil following irrigation with gravity and sprinkling methods. Spacing sprinklers 60 ft apart on the lines using an extra 30-ft length of pipe at each second setting of the portable line will result in a triangular spacing of distribution points of some 60 by 65 ft and give fairly uniform distribution, if the pressure is kept above 25 lb per sq in as a minimum. Various types of low-pressure sprinklers are now available that give fair distribution with a saving in power cost. Some overlap should be provided with low pressure perf-o-pipe to insure wetting down into the root zone at the middles between lines.

With gravity distribution the length of run between head ditches should be on the order of 220 ft on fine sand, 330 ft on loam, or up to 440 ft on clay loam, depending somewhat on the fall and size of stream. Excessive length of run may result in deep percolation loss in the upper part of the run before the water has penetrated the root zone in the lower part of the course. It is also more difficult to see what is going on from one end of the strip to the other with an excessively long run.

Irrigation will not take the place of nutrients, yet a rich, well-balanced soil solution will render sufficient the least amount of water per unit crop. This we regard as the first fundamental principle of irrigation practice.

Farming is the production of raw materials for food, clothing, and shelter. Farm income, just as industrial income, is beneficially affected by increased efficiency in farm operations. This picture shows the manufacturing of feed for the fattening of cattle on a farm near Elburn, Illinois. This machine follows closely a mower and side-delivery rake. The tractor supplies motive power and the operating power through a power take-off for picking up the green alfalfa, chopping it, and conveying it into a wagon. This alfalfa is then taken to a silo, where 70 pounds of corn molasses is added to each ton of hay as it is blown into a battery of large silos. This outfit can pick up and chop 20 tons of hay per hour. Oats, as well as alfalfa, are handled in this manner. The tractor is used at night for plowing and other farm operations

The Suitability of No. 2 Douglas Fir Dimension for Floor Joists

By Henry Giese
FELLOW A.S.A.E.

PROPER specification of materials is a problem constantly confronting the designer. He must on the one hand assure safety and satisfactory performance. On the other hand, he is adding unnecessarily to the cost if he specifies quality or quantity above that which will meet his requirements. All too often, due to inadequate data either as they may influence his judgment or code restrictions under which he must work, his specifications are unduly affected.

One illustration of this appears to be the use of Douglas fir for floor joists. Urban building codes usually, if not always, restrict the grade to No. 1 dimension. Rural carpenters operating outside the control of building codes frequently use No. 2. Is this use structurally satisfactory, or should code requirements be observed even in the rural areas? If the use of No. 2 material is satisfactory, should the code provisions be liberalized?

It is the purpose of this paper to review the situation both from the standpoint of the applied load and the ability of the material to perform and to report two series of tests on beams of No. 2 Douglas fir dimension.

Wood as a material has satisfactory structural properties. It has a very high strength weight ratio, is readily available, and is easily fabricated. It has, however, been severely penalized in design formulas because of certain inherent characteristics which lead to uncertainty in specification. Steel is a homogeneous material, refined and manufactured to high standards. Defective portions are thrown back and worked over. The tensile strength of steel is almost equal in its three dimensions. As a result of this, the stresses allowed in the design of steel structures are more than half that required to pass the elastic limit. The value has continued to be increased over a period of years.

The problem is not so simple when wood is used. Beyond the benefits which may be obtained by using skill and judgment in sawing, the lumber manufacturer is largely limited to sorting and culling according to standard grading rules. The material has appreciable tensile strength in one dimension only and the compressive strength varies greatly according to the direction of the grain. Knots, although indispensable to the growth of a tree, may be quite detrimental when the wood is used for structural purposes. These grading rules for "yard lumber" consider appearance only and no discrimination is made with reference to the location of defects and their probable effect upon the strength of structural members. Dimension lumber is usually cut from the center portion of the log where knots are to be expected. Because of the unequal shrinkage along the three dimensions of the piece, warping is more pronounced than for pieces cut farther from the center. Knots are common, and naturally more and larger ones are permitted in the No. 2 than in the No. 1 grade. Knots may be objectionable more perhaps because of their effect upon the

Journal Paper No. J-762 of the Iowa Agricultural Experiment Station (Project 563). First publication in AGRICULTURAL ENGINEERING. The author is professor of agricultural engineering, Iowa State College.

TABLE 1. ULTIMATE FIBER STRESSES AND CHARACTER OF FAILURE

Beam	Weight, lb per cu ft	Fiber stress, lb	Description of Failure
20-A	31.5	9790	Spike knot in top of beam failed in compression. Fibers in bottom parted in a clean break.
8-A	32.0	7960	Broke vertically at spike knot extending completely across one side of beam. Sheared off lower one-fourth of beam on one side of break.
9-A	28.6	7890	Split from small knot in bottom of beam not visible from either side.
24-A	30.1	7715	Splintered badly after crushing fibers around knot in top of beam.
16-B	30.5	7065	Crushed fibers around knot in upper edge and split along spike knot in lower half of beam.
21-A	31.5	6740	Pushed out small edge knot in upper edge and split diagonally from small knot near other side.
22-A	29.1	6725	Broke at large knot in center of beam 2 ft from load.
23-B	33.0	6290	Failed at knot in bottom edge—split diagonally to small knot near opposite edge.
15-B	32.5	5650	Split vertically along spike knot in center of beam 1 ft from load. Split diagonally to upper and lower ends of knot.
11-B	29.1	5060	Split from small knot near bottom diagonally to large knot in center of beam.
19-A	28.6	4940	Crushed fibers around small knot near top of beam and split diagonally from knot near opposite side.
3-A	32.0	4900	Failure began at small knot in bottom edge—split to large knot in center and diagonally to knot near top.
2-C	31.0	4840	Crushed fibers at knot in top edge—split along spike knot in lower three-fourths of beam.
5-A	30.1	4730	Split diagonally from very small knot in bottom edge to opposite side.
18-C	27.1	4275	Split diagonally from 1 ft one side of load to 4 ft on the other side. Clean break—no knots at failure.
7-C	29.6	4160	Crushed knot in top edge of beam. Beam splintered badly from resulting break.
12-C	26.1	3760	Failed at small knot near bottom 2 ft from load. Split to large knot in center of beam.
17-C	29.3	3665	Crushed fibers in several knots along upper edge. Parted at small knot in lower edge.
6-C	30.1	3407	Edge knot pushed out, split along spike knot in side of beam.
4-B	32.5	2885	Split from half knothole in bottom along diagonal grain—slope 15/16 in per 1 ft.
1-C	32.5	2715	Split at knot near bottom of beam about 36 in from load.
13-C	29.1	2714	Crushed fiber around knot in edge—split along spike knot to opposite side.
10-C	29.1	2714	Fibers crushed around spike knot in top three-fourths of beam.
14-C	32.0	2625	Split at spike, knot in top of beam, and knot near opposite edge.

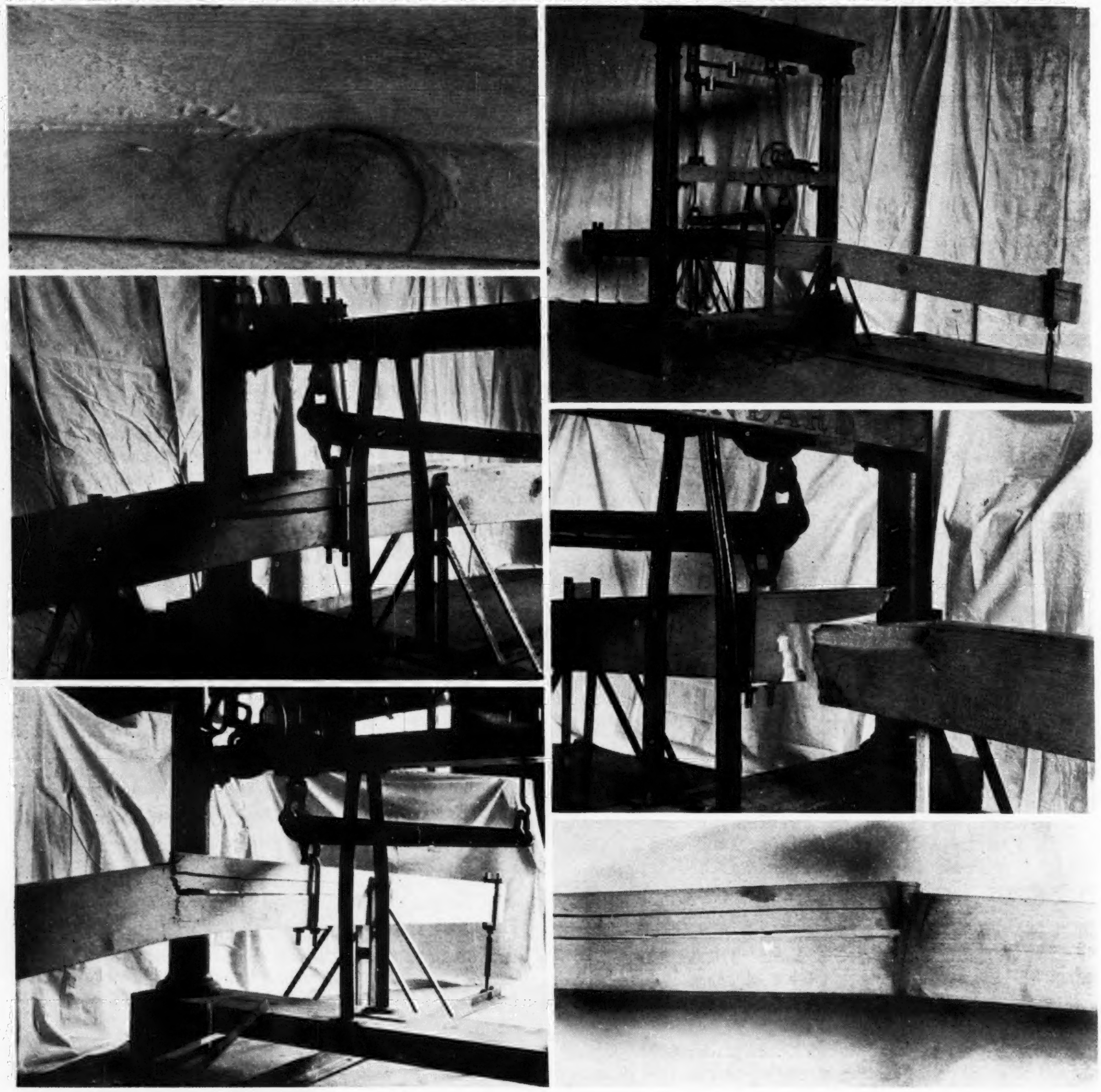


FIG. 1 (TOP LEFT) SEASONING CHECKS IN DOUGLAS FIR. FIG. 2 (TOP RIGHT) METHOD OF TESTING JOISTS. FIG. 3 (CENTER LEFT) FAILURE OF BEAM 3-A (LOAD, 4560 LB). FIG. 4 (CENTER RIGHT) FAILURE OF BEAM 20-A. FIG. 5 (BOTTOM LEFT) FAILURE OF BEAM 8-A. FIG. 6 (BOTTOM RIGHT) OPPOSITE SIDE OF BEAM 8-A

direction of the grain than because of their presence alone. Diagonal grain and particularly seasoning cracks along diagonal grain (Fig. 1) may greatly impair the strength of a beam. Wood varies greatly in density even in the same species. Moisture content has an appreciable effect upon strength. All of these contribute to a degree of uncertainty in design and a resulting conservative figure for allowable fiber stress.

This series of tests intended to be preliminary and exploratory only, were undertaken for the purpose of determining approximately what might be expected from No. 2 Douglas fir dimension when used for structural members such as floor joists.

In the first series, twenty-four pieces of 2x8-in No. 2 Douglas fir dimension, 12 ft long, were taken at random from the stock of an Ames lumberman. These were stacked and allowed to air-dry to about 11 per cent moisture content. The pieces were rated and grouped under three classifications according to apparent suitability for residential floor joists. Rating was made on a purely arbitrary basis, quickly and without definite specifications as follows:

A. Pieces which appeared to be of sufficiently high quality and with defects so located that the piece could be used satisfactorily as a joist.

B. Pieces with defects of such size and location that their use as structural members would be questionable.

C. Pieces of obviously little structural value.

Of the 24 pieces nine were given an A rating, five were judged to fall in the B group, and ten were classified as C.

The joists were supported on 11-ft centers and tested by applying a concentrated load either on one end or in the

TABLE 2. DEFLECTION OF BEAMS (SECOND SERIES)

	Applied load*, lb	Deflection of beams, in A	B	C	D	E	F	G	H	I	J	K	L
	50	0	0	0	0	0	0	0	0	0	0	0	0
100	150	.078	.058	.071	.072	.70	.071	.063	.084	.069	.066	.070	.075
200	250	.152	.117	.139	.142	.142	.140	.132	.172	.140	.130	.143	.157
300	350	.230	.178	.212	.216	.215	.213	.191	.261	.209	.194	.212	.238
400	450	.306	.238	.282	.290	.288	.283	.247	.352	.280	.254	.280	.314
500	550	.383	.300	.352	.364	.362	.355	.302	.444	.353	.317	.348	.393
600	650	.462	.361	.423	.436	.437	.425	.358	.534	.424	.378	.415	.472
700	750	.550	.419	.493	.510	.515	.496	.415	.626	.508	.439	.482	.552
800	850	.637	.480	.564	.583	.595	.570	.470	.719	.574	.503	.549	.635
900	950	.737	.542	.635	.657	.693	.673	.527		.643	.564	.615	.728
1000	1050		.607	.742	.733		.758	.594		.715	.625	.683	.788
1100	1150			.820	.805					.789	.684	.750	
1200	1250										.748	.820	
Weight of beam, lb		30	29	26.5	23.0	23.5	27	34	29	28	27	27	27
Equivalent deflection under 1000 lb uniform load		.375	.479	.440	.455	.453	.444	.378	.555	.441	.396	.435	.491

*Concentrated load.

center with a Buffalo (U. S. Standard) scale sensitive to 2 lb and with a maximum capacity of 5100 lb, the load being applied by a screw. A dial, calibrated in thousandths of an inch, afforded an easy measure of the deflection. The tests were carried to failure and the breaking loads and deflections recorded. Large knots appearing on the edge and near the center of the beam were placed, in so far as practicable, on the compression edge. Due to the inadequate extension limit of the screw, only the poorest beams could be broken where the load was applied at the end. The remainder of the beams were broken by a concentrated load at the midpoint with both ends supported by yokes bolted to the angle irons (Fig. 2).

In order to keep the beams in a vertical plane supports as shown in several of the photographs were placed at the quarter-points. These acted as guides for the beam, allowing free vertical movement but resisting horizontal movement.

An initial center load of 100 lb was applied to take up the slack in the apparatus and to compensate for the dead load of the floor. The strain gage was then set at 0 in and the load applied. The scale was kept balanced at all times,

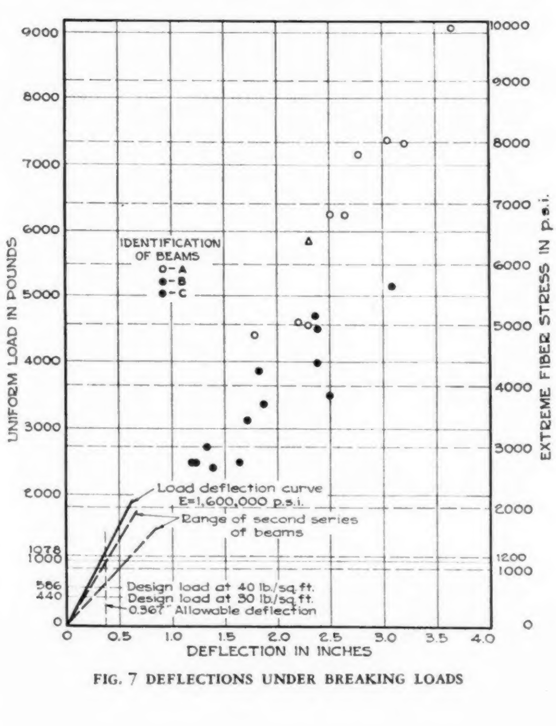


FIG. 7 DEFLECTIONS UNDER BREAKING LOADS

and readings on the strain gage taken. All strain gage readings are "gross" and include any deflections in the apparatus.

In addition, the total weight, the weight per cubic foot, the number of annular rings per inch at each end of the beam, and the angle the radius of the rings made with the 8-in side of the beam were all recorded.

The moisture content was read with a Tag-Heppenstal moisture meter at points about 18 in from each end and at the center.

The values for the loads and deflecting were converted to equivalent values for a uniformly loaded beam with the following relations:

$$W = 2P$$

$$Dw = 1.25Dp$$

where P = Concentrated load at midpoint

W = Uniformly distributed load that would give an equal bending movement

Dp = Deflection under concentrated load at midpoint

Dw = Deflection with equivalent uniform load.

It is quite obvious that present allowed working stresses for wood are very low. Miscellaneous Publication No. 185 of the U. S. Department of Agriculture gives a value of 2,000 lb per sq in for clear material of Douglas fir or southern yellow pine (not dense). This value allows a larger factor of safety than is usually assumed for other materials. Upon this assumed value, a 2-in joist need be only 4.23 in deep to successfully carry a 40-lb live load with a clear space of 11 ft. A 2x8-in joist (7½ in deep) is usually selected for this purpose. A 2,000-lb rating is, however, seldom if ever permitted by building codes. Because of the presence of defects or the probability of the material being weakened by becoming wet, a figure of 1200 lb is quite common.

Even if a higher figure were allowed, the depths might be limited by deflection which ordinarily is restricted to 1/360 of the span. If stiffness rather than strength determines the depth of a beam, there may be no structural advantage in using a clear timber.

It is evident from these tests that a joist may present a very poor appearance and still serve its purpose very well. Although ten of the twenty-four pieces were judged unfit for structural purposes, the poorest carried a fiber stress equivalent to 2625 lb and one carried 4840 lb. The group of ten averaged 3487 lb. While "average" strength may mean little, proper bridging and a double floor will assist in transferring load from a weak joist to a stronger adjacent one. Thirteen of the twenty-four beams exceeded 4800 lb, or four times a design figure of 1200 lb per sq in. Eight exceeded 6000 lb and one attained 9790 lb, more than eight

times 1200. The deflection of all beams tested was well within the tolerances allowed at the design load.

No. 2 material deserves more consideration for structural purposes than it has received. Along with this consideration, however, should come some method by means of which the pieces can be separated so that a minimum performance can be predicted.

Spike knots are perhaps the most objectionable defect. These may not be serious, however, if (1) they do not occur in the middle third, (2) if they can be placed on the compression side of the beam, or (3) if they extend through only a portion of the depth of the beam.

From Fig. 7 it will be noted that the rating of the beams into classes A, B, and C, by casual observation, was not a reliable measure of their structural performance. One reason for this is the fact that pieces with spike knots on the edge were given a C rating, whereas beams of this type performed fairly well when the knots were subjected to compressive stresses.

It is probable that one could estimate the strength more closely with experience. Twelve beams in a second series were tested in a similar manner to those in the first series (1) to extend the experience over a larger number and (2) to observe the deflections in the area of the design load. Random selection was made as before. Deflections are shown in Table 2, and comparison with the allowable is made in Fig. 7. It is apparent that although the elasticity of the beam fell considerable below the 1,600,000 frequently used for structural grades of Douglas fir, the deflection is well below the allowable at the assumed 40-lb per sq ft live load. Deflections under dead loads are neglected here since they are largely present when the plaster is applied, and the tolerance in deflection is fixed by that generally considered necessary to cause cracking of the plaster. Loading of this series was not carried to failure but discontinued at approximately three times the assumed live load.

Of the thirty-six pieces tested, none failed to meet the demands which might be placed upon them by the customary assumptions either as to live load or deflection. The twenty-four pieces which were tested to rupture, because of the presence of defects allowable in the No. 2 dimension grade of yard lumber, showed a range in ultimate fiber stress from 2625 lb to 9790 lb per sq in. The lowest one of the group thus provided a factor of safety of more than four over that required by a 40-lb per sq ft live load.

It may be reasonably argued that either one might occasionally find a piece of material of lower quality than those tested, or that the carpenter might fail to use good judgment and place the joists with large spike knots downward, or that the curvature of the piece would prevent locating knots on the compression side of the beam. It is recognized that a knot may not be equal in compression to straight-grained dense clear wood. The real problem lies in actual cracks at spike knots, thereby reducing the tension value to zero in which case any compression value would be an asset. The answer to the above is that a factor of safety ranging from four to approximately sixteen has been provided, and since the joists of a floor do not act as individual units, because of bridging and the tying in of the floor above, the weakness of an occasional defective joist will be compensated for by those adjacent to it.

It is also apparent that stiffness not strength is the limiting factor.

It is my belief, however, that the case is stronger than may appear from the above. Can we justify a live load rating of 40 lb per sq ft, or is it one of those traditions which might well be discarded. For a room 11 ft square inside measurement, which might use the 12-ft joists tested, the total assumed load would be 11x11x40 = 4840 lb. This is the equivalent of thirty-two persons averaging upwards of 150 lb. If thirty-two persons are ever assembled in a room of this size, it will not be a usual or ordinary occurrence. The factor of safety is provided for the extraordinary and unusual. One could scarcely conceive of sufficient furniture being placed in the room to bring the load to anywhere near the design figure. If we reduce the assumed load to 30 lb per sq ft or less, it becomes the more apparent that No. 2 Douglas fir dimension may be used successfully for floor joists.

BIBLIOGRAPHY

[1]Forest Products Laboratory. Wood Handbook. U. S. Dept. Agr. 1935.

[2]Markwardt, L. J. and Wilson, T. R. C. Strength and related properties of woods grown in the United States. Tech. Bul. 479. U. S. Dept. Agr. 1935.

[3]National Lumber Manufacturers' Association. Wood structural design data. Vol. 1. Second edition. Nat. Lbr. Mfrs. Ass'n. Washington, D. C. 1939.

[4]Wilson, T. R. C. Guide to the grading of structural timbers and the determination of working stresses. Misc. Pub. 185. U. S. Dept. Agr. 1934.

[5]Wilson, T. R. C. Strength moisture relations for wood. Tech. Bul. 282. U. S. Dept. Agr. 1932.

Principles of Tile Drainage

(Continued from page 310)

skilled ditchers, 0.05 per cent; with ordinary farm labor, 0.25 per cent. (Breaking the grade often saves much deep digging.)

3 Depth. At least 2 feet of cover over the tile. With the 4-inch size this will mean 29 inches to the ditch bottom.

It is often advisable to let the excavated material dry before it is replaced. Wherever possible, chip top soil around tile when blinding it to prevent the subsoil from cementing the joints. Occasionally, lime is added to very tight soils to flocculate the backfill before replacing it.

BIBLIOGRAPHY

[1]Graff, Dorothy W., Bibliography on Land Drainage, Bureau of Agri. Engin., U. S. Dept. of Agri., 1936. Mimeo.

[2]Haswell, John R., "Drainage in the Humid Regions," p. 723, "Soils and Men," 1938 Yearbook of U. S. Dept. of Agri. (Contains many references.)

[3]Haswell, John R., "Drain the Wet Spots," Agri. Ext. Cir. 112, The Pennsylvania State College, 1940.

[4]Jones, Lewis A., "Farm Drainage," Farmers' Bulletin 1606, U. S. Dept. of Agri., 1929.

The Farm Accident Problem

THE whole problem of accidents to farm people is fourfold. It includes: (1) deaths and injuries which occur in farm work; (2) those which occur in farm homes; (3) those which take place in going about the highways and streets; (4) those occurring in recreational and other public pursuits.

In 1939, 4,200 persons were killed in farm work accidents alone, according to estimates of the National Safety Council. Since the total losses in work accidents in all industries were 15,500 lives, these farm work fatalities represented almost 27 per cent of the whole.

In fact, more fatal accidents occur each year in farm work than in any other industry. Compare the figure of 4,200 deaths in farm work with the 3,500 deaths in trade and service, 2,700 in construction, 1,800 in transportation and public utilities, 1,800 in manufacturing, and 1,500 in mining, quarrying, and oil and gas wells.

About 1,250,000 persons are disabled each year in work accidents of all kinds; total economic cost of these injuries is about $600,000,000.—*From "Organizing for Farm Safety," Mimeograph of the National Safety Council, Inc.*

Terrace Maintenance

By C. L. Hamilton

TERRACING is now accepted as an essential measure for soil defense on much of our agricultural crop land. It is folly, however, to build terraces and not maintain them. The ultimate effectiveness of even well-constructed terraces depends on their being properly maintained and farmed after construction. Too often terracing projects or programs have failed because the importance of maintenance was not recognized at the outset or maintenance provisions were not properly incorporated with the initial field plans.

The rapid rate of decline in the effectiveness of terraces soon becomes evident after a short period of improper tillage and maintenance practices. Terraces that were constructed up to specifications in every respect have been rechecked after a single season of improper use, with astounding results. Instead of having ample channel capacity as originally constructed, many sections were found where the capacity had been reduced more than 50 per cent. This meant that with the next heavy rain the terraces would overtop and thereby aggravate rather than alleviate erosion.

Presented before the Soil and Water Conservation Division at the annual meeting of the American Society of Agricultural Engineers, at State College, Pa., June 19, 1940. The author is agricultural engineer, engineering division, Soil Conservation Service, U. S. Department of Agriculture.

PLOWING FOR TERRACE MAINTENANCE

(Top) A terrace channel plowed out as one land. (Center) The two-land method of terrace maintenance reconditions both the channel and the ridge. The ridge is plowed up with the first land and the second land is plowed up so that the deadfurrow between the two lands forms the center of the terrace channel. (Bottom) After terraces are reconditioned with the two-land method, the remaining interval can be plowed out as third land

The good effects of proper maintenance are just as striking as the ill effects of improper maintenance. Terraces have been observed that were even slightly undersized immediately after construction, but, with proper precaution and maintenance, were soon brought to adequate size and the cross section maintained or improved year after year. Some observations have even revealed that certain maintenance practices will actually increase the capacity of terraces year after year until they become larger than necessary.

Where soil conservation demonstration projects failed to provide for terrace maintenance from the outset, the results were discouraging. Farmers who were not impressed with the need for terrace maintenance or shown how it could be readily accomplished, unknowingly allowed their terraces to gradually deteriorate. By the time the seriousness of the condition was recognized, remedial measures developed, demonstrated, and adopted, terraced fields suffered seriously and many required rebuilding. Some projects purposely constructed extra large terraces to offset the expected lag in the adaptation of necessary tillage and maintenance practices. Even though this procedure is particularly tempting in areas where terracing is a new practice, it is a costly and often an impractical solution for bridging the gap between construction and the adoption of maintenance practices.

The fallacy of diverting funds to extra construction or other substitutes as a compensation for inadequate maintenance efforts, is evident. The only logical procedure is to inaugurate terrace maintenance activities as an inseparable part of a terracing program and provide necessary facilities for its development, demonstration, and adoption, so that maintenance will be appreciated and practiced from the outset.

Soil-conserving farm practices are required for the most economical and practical terrace maintenance. Soil-improving rotations, strip cropping, contour tillage, and like conservation practices will reduce materially the amount of work necessary for satisfactory terrace maintenance. Careful arrangement of row crops and close-growing vegetation in depressions or on critical slopes between terraces also minimizes maintenance requirements. The ideal objective is to utilize sufficient erosion preventives to minimize soil movement between terraces and thereby help to preserve their effectiveness.

Regular tillage operations on terraced fields should recondition the terraces as well as prepare the land for crops. Terrace maintenance then becomes an integral part of field culture and not a separate or extra practice. Necessary maintenance is also secured periodically with little, if any, additional cost. Many farmers think of terrace maintenance as extra work. Repairing breaks and washes caused by overtopping of unconditioned terraces is of course extra work, but ordinary terrace plowing should be considered a regular farm operation similar to seedbed preparation or

the harvesting of crops. When land is prepared by flat breaking or complete plowing, terrace maintenance becomes a part of land preparation at no extra cost.

In most areas it has been found that maintenance should begin immediately after fall crops are harvested. Teams and labor are usually available at this time, and it is important that terraces be brought up to proper size before new crops are planted. When terraced fields are in row crops, it is often advisable to plow the terraces twice each year. A wide row spacing astride the center of the channel will facilitate plowing out the channel while the crop is on the field.

To secure and maintain a desirable terrace cross section the plowman must exercise considerable ingenuity in selecting starting and finishing points under various field, slope, and terrace conditions. (A plow, one-way disk tiller, or any other tillage tool that produces suitable lateral soil movement may be used for terrace maintenance.) He must also be familiar with the terrace cross section required and with the principle of developing channels by plowing them out and improving ridge sections by backfurrowing. The whole trick is to plow in such a manner across the slope that each trip is effective in bringing the terrace to the right shape and size. The most desirable terrace cross section is governed by the type of terrace required[1], the land slope, and the size of tillage equipment to be operated over it. A terrace with comparatively flat side slopes and adequate water-carrying capacity must be provided.

MAINTAINING THE DRAINAGE TYPE TERRACE

The drainage or diversion type terrace serves primarily as a drainage channel to control surface runoff, thus retarding soil erosion. A wide, shallow channel of low gradient that has gentle side slopes and ample water capacity is desirable. The excavated earth forms the down-slope side of the channel. These requirements, together with the fact that it is easier to move earth downhill than uphill, make it advantageous to construct most, if not all, of the terrace from the upper side. In general, the drainage type terrace appears to be applicable to most terraceable areas in the humid sections of the United States when it is necessary to intercept and slowly drain the excess rainfall from cropland.

The One-Land Method. The one-land method of terrace maintenance is simply the plowing out of one land in the terrace channel. It is particularly adapted to fields where maintenance work is limited to channel reconditioning. The width of the plowed land will be at least 12 to 24 ft, depending on the slope of the field and the width of channel required. In plowing new terraces with narrow channels, the width of the land should be increased slightly at each plowing until the desired cross section is obtained. This will tend to increase the channel capacity, round out the bottom, and provide flatter side slopes.

The upper edge of the land is located above the desired center of channel a distance equal to that from the center of the channel to the top of the terrace ridge. The first furrow at the upper edge of the land may be thrown uphill, but if it is thrown downhill and the return furrow backfurrowed into it, the tendency for a ridge to form above the channel will be minimized. The first furrow slice on the ridge should be thrown downhill so that it just laps the center of the ridge. Plowing is continued until the channel is plowed out.

The Two-Land Method. The two-land method of terrace plowing is used where it is desirable to recondition the ridge of the terrace, particularly the downhill face, as well as the channel. The widths of the two lands can be adjusted according to the condition of the terrace and the improvement desired.

The first land is plowed by backfurrowing to the terrace ridge. If the first furrow slice is thrown downhill and just laps the center of the ridge, a peaked ridge formation will be avoided. This land is completed when the plowing extends to the desired center of channel.

The first round of the second land is made by backfurrowing parallel to the channel line and at least 12 to 16 ft up the slope. The location of the backfurrow may be varied at each plowing to prevent the formation of an objectionable ridge above the channel. The second land is completed when the plowing reaches the edge of the first land and the deadfurrow between the two lands forms the center of the terrace channel.

An acceptable variation of the two-land method can be obtained by first plowing out the terrace channel in the manner described for the one-land method. The second land is plowed by backfurrowing to the ridge. The upper ridge slope will therefore be plowed twice, and no soil will be thrown downhill above the channel. This procedure may be desirable to secure both channel and ridge maintenance where complete field plowing is not intended.

Plowing Terraced Fields. On terraced fields that are to be completely plowed, the plowing may be started by using either the one-land or two-land method on the terraces. If the terrace channels are plowed out first with the one-land method, the remaining interval from the top of the terrace ridge to the upper edge of the terrace channel below can be plowed out as a second land. Furrows on the upper half of this interval will be turned up the slope, and those on the lower half will be turned down the slope, leaving a deadfurrow in the center. If field plowing is begun by plowing with the two-land method, the remaining interval can be plowed out as a third land. The two methods may be alternated to advantage from year to year to vary the location of deadfurrows.

Although the two-way plow is not commonly used, it appears to have some distinct advantages for plowing terraced fields. Its use will eliminate the necessity of backfurrows and deadfurrows in undesirable locations and will simplify plowing. Another advantage is that all the furrows between terraces can be thrown up the slope. Turning the furrows uphill tends to offset the downhill soil movement caused by erosion and tillage. This type of plow has been used for plowing terraced land on several of the soil and water conservation experiment stations of the Soil Conservation Service and has shown good results.

Under unusual conditions, where it may not be possible to maintain proper terrace cross sections by the recommended methods of plowing, it will be necessary to do some supplementary terrace rebuilding. The lighter terracing machines, V-drags, or scrapers can ordinarily be used satisfactorily for this work.

Frequently plowing is not extended to the end of the terrace, or the outlet may sometimes be choked by dragging tillage equipment across it. The outlet ends of terraces should therefore not be overlooked in maintenance work. They must be kept open so the water will drain freely from the terrace channels.

MAINTAINING THE ABSORPTIVE TYPE TERRACE

The absorptive or retention type terrace should retain and distribute collected runoff over as wide an area as possible. These requirements, (*Continued on page 321*)

[1]The terrace types and classification used in this paper are described in "A national terrace classification," by C. L. Hamilton, AGRICULTURAL ENGINEERING, vol. 20, no. 3 (March, 1939).

Transport Wheels for Agricultural Machines

X. The Value and Cost of Pneumatic Tires

By J. Brownlee Davidson and Eugene G. McKibben
FELLOW (CHARTER) A.S.A.E. FELLOW A.S.A.E.

AGRICULTURAL machines for many years have been quite generally equipped with steel transport wheels, these steel wheels having replaced the wooden wheels of an earlier period. At the present time many machines are being fitted with pneumatic tires which have come to be used universally on the automobile and extensively on the farm tractor. This paper has been prepared in connection with an extended study of pneumatic tires for transport wheels on farm machines and represents an effort to summarize the results of the researches completed in terms of economic relationships.

The researches on pneumatic tires have been directed toward securing information along three general lines, viz.:

1 The influence of the pneumatic tire upon rolling resistance.

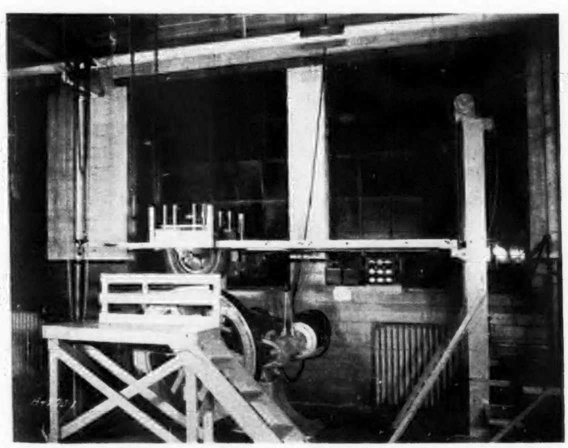
2 The protection from shock, caused by contact with an obstruction on or an unevenness of the road surface.

3 The relationships between the soil and the wheel as influenced by the pneumatic tire.

Although it is impossible to appraise with exactness the value of the various advantages and benefits which may be secured from the use of pneumatic tires, this paper will set forth some of the principles which may be used in their appraisal and also point out for comparison the customary items comprising the cost of using pneumatic tires.

Attention is called to the nine previous papers which have appeared monthly in AGRICULTURAL ENGINEERING, beginning with November, 1939, and continuing to date under the general title, "Transport Wheels for Agricultural Machines."

Journal Paper No. J-784 of the Iowa Agricultural Experiment Station, Project 576, in cooperation with the American Society of Agricultural Engineers. Articles I to IX of this series have appeared consecutively in AGRICULTURAL ENGINEERING from November 1939 to July 1940, inclusive. This article concludes the series. The authors are, respectively, professor and associate professor of agricultural engineering, Iowa State College.



Apparatus for measuring the force of impact due to a transport wheel striking an obstruction on the road surface. The apparatus proved to be very effective in demonstrating the protection from shock to a machine afforded by a pneumatic tire

Rolling Resistance. In the experiments previously described, the rolling resistance was measured for six steel and seventeen pneumatic-tired wheels, each with three loads and under four road and field conditions. Numerous additional tests were made to determine the influence of specific conditions of road surface or wheel arrangement on rolling resistance.

It was observed that while pneumatic tires actually increased the rolling resistance slightly over that for load carrying steel wheels at slow speeds on a smooth concrete surface, they reduced the rolling resistance as much as 46 per cent on a tilled field. It is easily recognized that, for all practical purposes, the cost of moving a load over any road surface is proportional to the rolling resistance. With rather full knowledge of any situation relative to the cost of tractive power and road or field surfaces, it is possible to estimate the saving in transportation cost due to reduced rolling resistance. To illustrate, assume a situation where the cost of drawbar horsepower is ten cents per hour, where the speed is 3 mph (miles per hour) and the drawbar pull is 125 lb per horsepower. If a load of one ton is to be moved over a tilled surface, the data available indicates that the rolling resistance is 450 lb when carried on a 6x28-in steel wheel and 322 lb when carried on a 6.00-16-in pneumatic tire inflated to 20 lb air pressure[1]. The power required to move the load on steel wheels under the condition specified would be 3.6 dbhp (drawbar horsepower), while on the pneumatic tire the power would be 2.6 dbhp, or a saving of 1dbhp. This would indicate that for every hour the machine in question is used under these conditions, the saving in power alone would be 10 cents per hour.

The annual saving, which may be used to determine a sound economic investment, would be determined by multiplying the hourly saving by the annual use of the machine in hours. This saving for 100 hours would be $10.00.

Similar estimates for the saving per hour due to reduced rolling resistance can be made for other situations. It should be fully emphasized that the saving thus estimated, due to lower rolling resistance, is for one condition only, and for any other condition, although susceptible to estimate, it would be different.

Protection from Shock. One of the principal advantages in the use of pneumatic tires is the protection afforded to the machine from shock due to impact with obstructions or unevenness of the road surface. The cushioning effect provided by the pneumatic tire makes for longer life or greater durability of the machine, because of less breakage and less wear on the working parts, and for greater comfort to the operator. In order to gain some knowledge concerning the nature of the protection from shock, special apparatus was constructed in the laboratory for measuring the shock from

[1]See Table IV, p. 472, AGRICULTURAL ENGINEERING, vol. 20, no. 12, December, 1939.

obstructions of known height and at different speeds. The apparatus consisted essentially of a drum which could be driven by an electric motor at a surface speed of approximately 2½, 5, 7½, 10, 15, and 20 mph. A carriage or frame in which a wheel could be mounted and hinged at one end was so placed that the wheel under test came directly over the drum and was permitted to roll freely on the drum as it was driven at the various surface speeds. The wheel was loaded by weights so distributed that their center of mass came directly over the axle. Provision was made for mounting obstructions on the drum varying from ½ in to 2 in in height by ½-in increments. The effect of the impact of the wheel with an obstruction when rolling over the drum was measured by a six-element solenoid type accelerometer[2]. This instrument which has been described briefly in the first paper of this series[3], measured the acceleration from which the force of impact was calculated. Some of the observations are given in Table 1[4].

TABLE 1. IMPACT REACTIONS OF A STEEL WHEEL AND A PNEUMATIC-TIRED WHEEL OVER OBSTRUCTIONS[4]

Wheel	Speed, mph	Height of obstruction, in	Acceleration, ft-sec²	Impact lb	Remarks
Steel wheel, 24-in diam	2.5	½	200	6030	
4-in rim	5.1	½	495	14900	Wheel deformed by impact
Pneumatic	2.5	½	none	——	
tire,	10	½	none	——	
6.00-16,	21.7	½	none	——	Slight vibration
20 lb	21.7	1	12	372	" "
inflation	21.7	1½	41	1273	" "
	21.7	2	48	1490	" "

Watching the impact experiments with the apparatus described was much more impressive than the tabulated data. A loaded steel wheel rolling over a half-inch obstruction at five miles per hour was subject to a terrific blow accompanied by a loud report. A six-inch pneumatic tire carrying the same load, on the other hand, was apparently little affected by a half-inch obstruction, and even when the height of obstruction was increased to two inches and the speed increased to twenty miles per hour, the conditions were apparently not impractical for operation.

The protection from shock due to impact was further studied by road tests of two identical machines, one on steel wheels and one on pneumatic tires. The results of these tests were reported in the first paper[3] of the series.

Although it is impossible to fully appraise the value of the protection to a machine afforded by pneumatic tires, it is fairly easy to draw some definite conclusions from the observations which have been made. These may be summarized as follows:

1 The use of pneumatic tires on farm machines is imperative if field and road speeds are to be higher than 2½ to 3 mph, the speeds established for horse-drawn machines.

2 The life of a farm machine should be lengthened even at normal horse-drawn field machine speeds, but the scope of the experiments here reported do not indicate how much.

3 The added comfort of operating a pneumatic-tired machine on which the operator rides over a machine with rigid wheels is easily demonstrated, but not susceptible of exact evaluation.

Soil Relationships. The results of the experiments for determining the relative effects of steel and pneumatic-tired wheels on the soil have been reported in a special paper[5]. These experiments indicated the following:

1 The pneumatic tire damaged temporary field roads much less than steel wheels, especially when a low inflation pressure was used.

2 Only about one-fifth as much soil adhered to the pneumatic tire during operation on wet sticky soil.

3 The pneumatic tire lifts much less dust to sift into the wind than the usual steel wheel.

These advantages, not easily appraised, should be taken into account when considering the advisability of pneumatic tires for any machine.

Cost of Pneumatic Tires. As is frequently the case in considering the advisability of an investment in equipment, the advantages and savings must be weighed against the cost of use of the equipment. The problem ranges all the way from the situation where there is no question in regard to the advisability of an investment to another situation where an investment is clearly inadvisable. In the case of pneumatic tires for a vehicle or machine which is to be operated at high speed and subject to serious shocks, there can be no question but what pneumatic tires are not only economical but necessary. On the other hand, a machine operated at slow speeds on favorable surfaces for a few days per year may not present a favorable situation for such an investment.

A number of factors influence the various items that make up the cost of using pneumatic tires as is the case with other equipment. These factors or individual items are usually listed as follows: first cost, depreciation, interest, taxes and insurance, and maintenance.

It is not definitely known how long tires for farm machines may be expected to last, but it may be presumed that they would last as long or longer than tractor tires whose life was recently set at an average of seven years[6]. Most observers contend that since the service expected of pneumatic tires on farm machines is not severe, the life is more or less independent of the use in days per year. Using the available information, it may be estimated that the cost of a pneumatic tire in terms of per cent of first cost is as follows:

TABLE 2. ANNUAL COST OF TIRES IN PER CENT OF FIRST COST

	Life 6 yr	7 yr	8 yr	10 yr
Interest at 6 per cent and depreciation[7]	19.2	16.9	15.2	12.8
Storage, insurance, and taxes	1.1	1.1	1.1	1.1
Maintenance repairs	2.0	2.0	2.0	2.0
Total annual cost, per cent	22.3	20.0	18.3	15.9

[2]Accelerometer supplied through the courtesy of the Firestone Tire and Rubber Company.

[3]Transport wheels for agricultural machines. AGRICULTURAL ENGINEERING, vol. 20, no. 11, p. 420, November, 1939.

[4]The impact apparatus was designed, built, and operated by P. J. Patel, formerly a graduate student, now with the University of Bombay, India. The research is reported in an unpublished thesis, Impact Characteristics of Transport Wheels for Agricultural Machines, Iowa State College, 1939.

[5]AGRICULTURAL ENGINEERING, vol. 21, no. 5, pp. 183-185, May, 1940.

[6]Life, Service, and Cost of Service of Pneumatic Tractor Tires. Bul. 382. Iowa Agr. Exp. Sta., September, 1939.

[7]See any table of condition per cent for compound interest and sinking fund.

TABLE 3. USE, KIND OF POWER USED, AND WEIGHT OF THE MORE COMMON FARM MACHINES[8]

Machine	Per cent farmers having machine	Per cent tractor drawn	Days used per year	Size	Weight, lb*	No. of wheels	Distribution of weight
Gang plow	29.5	0	8.2	2-12	900	3	1/3 each
Tractor plow	87.0	100	15.6	2-14	900	3	1/3 each
Broadcast seeder	78.5	48	3.4	11-ft	700	2	1/2 2 or mounted on wagon
Grain drill	26.3	45.7	5.6	14-7	1800	2	1/2 each
Corn planter	98.3	8.9	6	2R	750	2	1/2 each
1-row cultivator	71.0	0	9.9	1R	700	2	1/2 each
2-row cultivator	28.8	0	11.8	2R	1200	2	1/2 each
Mower	97.0	1.7	8.8	6-ft	1000	2	1/2 each
Hayrake	50.0	1.5	5.1	12-ft	700	2	1/2 each
Side-delivery rake	64.5	11.2	6.6	12-ft	1100	3	1/3 each
Hay loader	62.0	25.4	8.0		1500	4	2, - 3/8; 2, - 1/8
Grain binder	79.5	56.6	4.9	8-ft	2200	2	1, - 3/4; 1, - 1/4
Corn binder	40.0	33.5	5.2	1R	1900	2	1, - 3/4; 1, - 1/4
Combine	15.5	100.0	21.8	5-ft	3000	2	2, - 1/2 each
Corn picker	31.0	99.2	14.3	2R	3500	2	2, - 1/2 each
Manure spreader	94.0	8.5	27.7	with load	4800	4	2, - 5/16; 2, - 3/16
Wagon	87.0	6.0	37.4	with load	5000	4	4, - 1/4 each
Trailer, 2-wheel	21.0	——	8.8			2	2, - 1/2 each
Trailer, 4-wheel	22.0	——	8.8			4	4, - 1/4 each

*Includes approximate weight of machine in common use plus operator and load.

If the foregoing premise that the life of a tire is independent of annual use is correct, and observations seem to support this view, then the most important factor in reducing the cost of pneumatic tires is increased annual use. For instance, if the annual cost of a tire is $2.50 and the use is five days per year, the cost per day would be 50 cents. But on the other hand, if the use were fifty days, the cost per day would be only five cents per day.

A significant feature of farm machines compared with factory equipment, for example, is the limited use per year. Table 3 from data recently compiled in Iowa gives the average annual use of the more common farm machines; for a purpose explained later in the discussion, a nominal weight of each machine is added

Interchangeable Tires. The foregoing table is used to point out how many of the more common farm machines have a very limited use in days per year and how desirable it may be to have interchangeable tire equipment as far as possible. The machines used more than ten days are only six, viz.: tractor plow, cultivator, combine, corn picker, manure spreader, and wagon, and the use of the first four are seasonable. The advantages that would accrue from practicable interchangeability is obvious from an inspection of the annual use.

Standardization of Sizes. Owing to the fact that farm machines, for the most part, were designed without any influence from the size of pneumatic tire which might be used, a large number of tire sizes have been offered to meet the wide range of existing farm-machine wheel sizes. Manufacturers realize that this large number of sizes means greater expense for manufacture due to cost of molds, stocks required, and other similar expense. They have through cooperative effort reduced the number of certified sizes from 118 to 73 and are working toward still further simplification. An ideal situation would be where less than a dozen tire sizes could be made to meet all requirements.

It should be pointed out that tires may be used either in a dual or tandem arrangement, and the cost of the two smaller tires may be less than that of a single of equal capacity. A four-ply, 6.00-16-in pneumatic tire which has a load-carrying capacity, when used on an agricultural machine at 28 lb inflation pressure, of 1240 pounds, could presumably meet the requirement of 41 of 49 wheels listed in Table 3, and six additional conditions when used as duals or tandems. To use this size, however, many machines would need to be redesigned. It may be pointed out, in support of the suggestion that developments should be in this direction, that in the year 1939, 48 per cent of the tires sold for farm implements were of the 5.00-16, 6.00-16, 6.50-16, and 7.00-16 sizes[9]. It should be recognized that a number of the latter two sizes were six-ply which have a greater load carrying capacity than the more common four-ply tire.

Use of Automobile Tires. There would be an important economic advantage in using tire sizes on farm machines or trucks. Not only should the price of such sizes be favorable, but the ease of securing them a matter of convenience. Owing to the fact that the service of tires on farm machines operating at slower speeds is less severe than on an automobile at high speed, and the safety hazard of using such tires for a longer period is less, there is much economic encouragement to transfer automobile tires to farm machines for further use at 15 to 25 per cent of first cost. There seem to be valid reasons why such a practice should be encouraged.

Viewing the problem of equipping agricultural machines with pneumatic tires in its broader aspects, it seems that a careful weighing of the information available would support the proposition that, *if the economic and design problems of interchangeability and standardization are properly met, all tractor-drawn field machines should and probably will, with few exceptions, be carried on pneumatic tires within a comparatively short time.*

[8]Unpublished data from recent investigation in Iowa. S. M. Henderson, Iowa Agr. Exp. Sta. 1940.

[9]Farm Implement News, June 13, 1940.

Terrace Maintenance

(Continued from page 318)

together with the flat slopes encountered, favor construction from both sides so that a broad embankment that extends well above the ground surface is formed. Unnecessary excavation above the ridge or embankment encourages undesirable runoff concentration and uneven moisture distribution. In general, this type terrace is applicable to the pervious soils and flatter slopes of semiarid areas. Erosion control is accomplished indirectly. The added moisture produces a soil condition that is more resistant to wind erosion and facilitates the establishment of crops and other protective vegetal coverings.

The One-Land Method. Since the ridge of the absorptive terrace is of primary importance and the channel merely incidental to its construction, appropriate maintenance should be directed toward improving or reconditioning the ridge. This necessitates a one-land method of maintenance which involves backfurrowing to the terrace ridge with sufficient rounds to plow the terrace section. After the terrace section is plowed up in this manner, plowing may be continued around each terrace until the remaining intervals are plowed out. When advisable, the terrace intervals may be plowed out as a second land by backfurrowing toward the center. Where it is not customary to plow in preparing crop land any approved regular tillage practice may be used on the interval between terraces.

A Variable Width Plow

By E. V. Collins and C. K. Shedd
MEMBER A.S.A.E. FELLOW A.S.A.E.

A VARIABLE-width plow provides a means of adjusting the width of furrow to the resistance of the soil. As made for experiments conducted at the Iowa Agricultural Experiment Station, it consists of a conventional one-bottom tractor plow with a 16-in bottom to which has been added a left-hand 7-in bottom made from one-half of a conventional lister bottom, so mounted that the shins of the two bottoms coincide as closely as possible and the 7-in bottom cuts 1.5 in shallower than the 16-in bottom. The furrow slice of the small bottom is thrown onto the unplowed land, the effect being to fold a 23-in furrow slice into a 16-in width which is turned by the 16-in bottom on the next trip through.

The attachment can be removed in a few minutes if plowing conditions are such that a 16-in bottom is a more suitable load for the tractor. Landside pressure is effectively reduced by this attachment, but, since the small furrow is thrown against the unplowed land instead of into an open furrow, the draft per square inch of furrow cross section should be affected very little as compared to conventional plowing. A limited number of draft tests indicate that there is no consistent advantage in draft per square inch of furrow turned.

With emphasis on the desirability of turning under corn stalks and other crop residues, it has been found that 12-in bottoms, especially if used in gangs, are unsatisfactory on account of poor coverage and clogging. To a lesser degree 14-in are less effective than 16 or 18-in plows.

As a result of these conditions, the user of the small tractor has had to choose between the disadvantage of two 12-in bottoms or the reduced capacity of one 18-in bottom, and whichever he selects he will use for both the hard and easy plowing. With the plow described, it is proposed to turn a 23-in width in easy plowing such as cornstalk or soybean ground and use the conventional 16-in width for hard plowing conditions such as alfalfa sod. It would appear that this attachment is especially advantageous for mounted plows on small tractors. It overcomes most of the landside pressure which is especially bothersome with this type of plow, permits the plow to be mounted 7 or 8 in nearer the center of the tractor, and loads these tractors nearer to their capacity in plow gear.

It appears that the need for a jointer is largely eliminated with this plow, because a 16-in width of furrow slice is being turned into a 23-in furrow, so one furrow slice does not lap onto the next as with regular plowing, yet the ridging is slight if used at speeds over 3 mph.

Another distinct advantage is that the single coulter is held down by the suction of the 23 in of plow in addition to the weight of the plow itself. In throwing soil both ways, any trash collecting ahead of the beam is more likely to go one way or the other than with a regular plow.

In addition to the plow described, a right and left-hand mounted plow has been fitted with these attachments, as has also an 18-in tractor plow, in which case a 9-in left-hand bottom was used as the attachment. The operation of all these units has been satisfactory. A similar two-bottom unit is under construction for use with larger tractors. Such a unit should have distinct advantages in trashy conditions. By using two 18-in bottoms with 9-in attachments, a total coverage of 54 in can be obtained for easy plowing conditions, and it is anticipated that the adjustable feature will be practicable in this plow so that it can be quickly changed to a 36-in width.

As these experimental units have been constructed, with the attachment cutting 1.5 in shallower than the regular bottom, the plow sole is left irregular. That is, if the loosened soil were removed from the plowed field, ridges 7 in wide would alternate with 16-in depressions 1.5 in lower than the ridges. It has been suggested that this ridged plow sole might be of advantage in reducing erosion. If this feature is found objectionable, the two bottoms could be made to run at the same depth and the side thrust carried by other means. Another excuse for using a different working depth for the attachment is that a 14-in lister, from which the attachment was made, is designed to cut shallower than does a 16-in plow.

It has been found most advantageous to run the tractor drivewheel in the corner of the part of the furrow 16 in deep, rather than on the 7-in shelf next to the unplowed land. With tricycle-type tractors the right drivewheel should be so set that the front wheels will run just to the left of the soil thrown on the land by the left-hand bottom.

Journal Paper No. J-759 of the Iowa Agricultural Experiment Station, Project No. 395. The authors are, respectively, research professor of agricultural engineering, Iowa Agricultural Experiment Station, and agricultural engineer, Bureau of Agricultural Chemistry and Engineering, U. S. Department of Agriculture.

(LEFT) A 7-IN LEFT-HAND BOTTOM ATTACHED TO THE LEFT OF A CONVENTIONAL 16-IN RIGHT-HAND BOTTOM, FOR PLOWING A STRIP 23 IN WIDE. (RIGHT) THE VARIABLE-WIDTH PLOW IN OPERATION USING BOTH BOTTOMS

NEWS

North Atlantic Section Program for Maine Meeting

MEETING in Maine for the first time, the North Atlantic Section of the American Society of Agricultural Engineers will be joined by the New England Rural Electrification Institute in a program at the University of Maine, Orono, August 27-30.

Entertainment, including moving pictures of "Wildlife in Maine," one by the New England Telephone and Telegraph Company, and others featuring Maine, is planned for those who arrive Tuesday evening, August 27. Sessions are scheduled to open Wednesday morning, August 28, with greetings by Dr. A. A. Hauck, president of the University of Maine; a welcome by Dean A. L. Deering of the College of Agriculture; and a message from the chairman of the North Atlantic Section, W. T. Ackerman. The morning session will also include papers on "Potato Experimental Work in Maine," by Dr. Fred Griffee, director of the Maine Agricultural Experiment Station, and on "Rural Electrification in Maine," by John W. Leland, director of rural service, New England Public Service Co. M. G. Huber will preside at this opening session.

In the afternoon session attention will be focussed on "Agricultural Engineering in the Soil Conservation Program," by C. A. Frye; "New Developments in Poultry Housing," by Roy E. Jones, extension poultryman, University of Connecticut; and "Cooperative Relations and Organized Effort for Farm Building Service," by Wallace Ashby. A. M. Goodman is to be chairman for the session.

EVENING ROUNDTABLE SESSIONS

Roundtable discussions are scheduled for the evening of the same day. A. A. Stone is to be in charge of one on "Power, Machinery, and Soil Conservation." Discussion starters for this group will be "High-Low and Unequal Band Placement of Fertilizer," by Fred Bateman, A. B. Farquhar Co., and Dr. J. A. Chucka, professor of agronomy, University of Maine; and "Machinery for Terraces and Hilly Land," by J. W. Slosser.

For the roundtable on "Rural Electrification," E. C. Hathaway, commercial manager, Central Vermont Public Service Co., will preside and introduce Neal D. Herrick, who will speak on "Irrigation in New England Farming," G. L. Munroe, whose topic will be "Grounding the Farm Wiring System," and H. N. Stapleton, with a contribution on "Electric Steam Boiler Equipment."

W. C. Krueger is to preside over a "Farm Structures" roundtable for which discussion priming subjects and speakers have not yet been announced.

RURAL ELECTRIC DAY

Thursday morning and afternoon, August 29, are to be devoted to the program of the New England Rural Electrification Institute. In the morning A. V. Krewatch will preside over a session featuring "The New Code and What It Contains," by M. H. Lloyd; "The Brooder and Battery in Poultry Production," by Dr. John C. Scholes, Beacon Milling Co.; and "Informational Publications for Electric Consumers," by J. P. Schaenzer.

F. L. Rimbach will occupy the chair for the afternoon session, which offers "Electricity in the Farm Home," by Edna M. Cobb, home management specialist, University of Maine; "A Small Electric Pasteurizer," by Maurice W. Nixon; and "Quick-Freeze and Storage of Fruits and Vegetables," by George W. Kable.

A short business meeting of the North Atlantic Section is to be held at the close of this session.

Joseph S. Webb is slated as toastmaster for the yearly banquet of the Section, scheduled for the evening. "Humorous Recollections" by A. L. T. Cummings are promised as the substance of the address of the evening.

Frank Hamlin will preside over the closing session Friday morning, August 30. It is to open with J. H. Bodwell discussing "All Electric Dairy Rooms." "Potato Production Methods in Maine" are to be summarized by several prominent potato growers of the state. This feature is to be supplemented by a motion picture, "Wings Over Aroostook." The closing feature will be "Recent Progress in Safeguarding Silos for Grass Farming," by H. E. Besley.

Tours, inspections, and demonstrations offered for the afternoon include a paper mill, the Old Town Canoe factory, soil testing with particular reference to frost action in highways and building foundations, a novelty woodwork factory, and the Old Town Indian Reservation.

Entertainment for visiting ladies will include, in addition to the Section banquet and home management items on the regular program, a visit to the Old Town Indian Reservation, an afternoon tea, a tour of the University of Maine Campus, and a trip to Bar Harbor and Acadia National Park.

ACCOMMODATIONS AND ROUTING

Lodging and meals will be provided in the new Estabrook Hall at the University. Requests for room reservations should be addressed to M. G. Huber, College of Agriculture, University of Maine, Orono, Me. Necessary costs for staying at the University will be low. Persons travelling to the meeting by auto from the south and west are advised to travel through Portsmouth, N.H., Portland, Brunswick, and Bangor. Recommended rail service from Boston is via Boston and Maine R.R. to Portland, and Maine Central R.R. to Bangor. Orono is a short ride from Bangor. Additional information may be obtained from Mr. Huber or from W. T. Ackerman or H. N. Stapleton.

Nominations Invited for 1941 A.S.A.E. Medal Awards

IN accord with the rules governing the award of the John Deere and Cyrus Hall McCormick gold medals, the Jury of Awards of the American Society of Agricultural Engineers will receive from members of the Society, up to October 1, nominations of candidates for these two awards for the year 1941.

Members of the Society nominating candidates for either award are requested to keep in mind the purposes of each medal and formulate their nominations accordingly. The John Deere medal is awarded for "distinguished achievement in the application of science and art to the soil," which citation is interpreted to cover more than a mechanistic concept of engineering, and to include chemistry, physics, biology, and any other science and art involving the soil, the "application" being acceptable to "evaluation by the engineering criteria of practicality and economic advantage."

The Cyrus Hall McCormick medal is awarded "for exceptional and meritorious achievements of a continuing career or to any single item of engineering achievement, and to apply equally to all special fields and types of engineering in agriculture.

The Jury of Awards desires that members of the Society consider it their duty and obligation to give serious thought to the matter and nominate for either or each of these awards the men they believe to be most worthy of the honor. Each nomination must be accompanied by a statement of the reasons for nominating the candidate and the qualifications of the nominee, including his training, experience, contributions to the field of agriculture, a bibliography of his published writings and any further information which might be useful to the Jury in its deliberations. The Jury will accept and consider nominations received on or before October 1, and these nominations should be addressed directly to the Secretary of the Society at Saint Joseph, Michigan. The Secretary will be glad to supply on request an outline of the form and contents of presentations to accompany nominations for consideration by the Jury of Awards.

Additional information on the history, significance, and description of these medals will be found in AGRICULTURAL ENGINEERING for May 1932 (McCormick medal) and October 1937 (Deere medal).

(News continued on page 326)

A.S.A.E. Meetings Calendar

August 27-30—North Atlantic Section, Orono, Me.

December 2-6—Fall Meeting, technical divisions, The Stevens, Chicago, Ill.

June 23-26, 1941—Annual Meeting, Knoxville, Tenn.

Washington News Letter

from AMERICAN ENGINEERING COUNCIL

NEW EXECUTIVE SECRETARY

COLONEL L. B. LENT, well known as an engineer, inventor, and trade association executive, has been appointed executive secretary of the American Engineering Council and has assumed his new duties. He succeeds Frederick M. Feiker, who resigned several months ago to become dean of engineering at George Washington University. Col. Lent is a native of Brewster, N. Y., and a graduate of Stevens Institute of Technology, Hoboken, N. J.

Recently, Colonel Lent has been a consultant in the aviation field, especially as engineer to the Aeronautical Development Commission of the State of Connecticut.

* * *

COMMITTEE WILL ADVISE ON PAN AMERICAN RELATIONS

Responding to an invitation by the Department of State, Col. L. B. Lent, executive secretary of American Engineering Council, and C. O. Bickelhaupt, chairman of its Committee on Inter-American Engineering Relations, on August 1 conferred with Charles A. Thomson, Harry H. Pierson, and Richard Pattee, of the Division of Cultural Relations, relative to specific methods by which the committee can lend its advice and assistance to the State Department. The discussion centered about facilities for the introduction to the profession of engineers arriving from abroad, specifically the eight Latin-American students soon to arrive in this country to attend the 1940 A.S.A.E. Industry Seminar, as well as others expected to come later under the exchange plan now being inaugurated.

The State Department has asked Council to broadcast the information among its members that many requests are being received from abroad for informative educational motion picture films reflecting the life, ideals, and customs of the United States. While a certain number of government films are available, the Department could meet these requests more adequately if it had available for distribution films of this type produced by other than government agencies, and it is hoped that these will be made available by those who have them.

* * *

DRIVE FOR FARM SAFETY

Recognition of the fact that accidents constitute one of the largest leaks in farm income has led the Farm Security Administration to instruct its field force in the recognition and elimination of hazardous conditions, particularly relating to fire prevention, protection against falls, the handling of machinery, and dangerous animals. In industry, it is pointed out, accident rates have been greatly reduced by education and the provision of proper safeguards, and equally good results can be expected from their application to farm conditions.

* * *

PLAN BOARD SURVEYS U. S.

Facts and figures regarding many factors entering into the trend of American life are gathered together in a recent report of the National Resources Planning Board. Topics considered include population trends and their effects, national income, transportation, agriculture, national resources, education, and public works. Some of the conclusions reached are:

U. S. population will increase to 158,000,000 by 1980, thereafter remain stationary or decline. Between 1935 and 1975 the number of persons aged 20 to 44 will increase by only 6 per cent, while those in the age group 45 to 64 will increase 69 per cent. Enrollment in schools and colleges will increase for several years, then level off.

Planning on a national scale is necessary to make the most effective use of resources in many fields. For example, conflicts among railroads, highways, airways, waterways, and pipe lines result in unnecessary duplications of service and high costs.

Personals

E. M. Dieffenbach, associate agricultural engineer in the U.S.D.A. Bureau of Agricultural Chemistry and Engineering, was recently transferred to the Bureau of Entomology and Plant Quarantine with headquarters at Gulfport, Miss., where he will have supervision of spraying, dusting, and other engineering problems in the control of the white-fringed beetle, in the eradication and control of which pest portions of Louisiana, Mississippi, Alabama, and Florida are included.

Frank B. Lanham edited the annual report of "Research and Investigational Activities," of the College of Agriculture, University of Georgia, for the fiscal year ending June 30, 1940. It is a 6x9-in bulletin of 74 pages. Reports published in it include contributions by *F. W. Peikert* and *S. T. Moore* on "Investigation of a Low Cost Threshing Machine," by *J. B. Greiner* on "Heating the Homemade Brooding Unit with Electricity," by *W. E. Hudson* and Mr. Lanham on "Investigation of Barn Hay Drying System as Applied to Georgia Conditions," and by Mr. Peikert on "The Effect of Tire Wear on Tractor Wheel Slippage."

Ralph L. Patty is author of "Paints and Plasters for Rammed Earth Walls," Bulletin 336 of the South Dakota Agricultural Experiment Station.

V. S. Peterson is author of "Mower Adjustment and Repair," Pennsylvania Agricultural Extension Circular 224.

A. J. Schwantes was appointed June 15 by the board of regents of the University of Minnesota as chief of the division of agricultural engineering of that institution. During the past year Mr. Schwantes has been serving as acting head of the division. He has for several years been a member of the agricultural engineering staff of that institution.

James L. Shepherd has been appointed to fill a position as associate professor of agricultural engineering at the University of Georgia. Until his appointment he was employed on the instructional staff at Abraham Baldwin Agricultural College.

Maxton D. Strong, a research fellow in the agricultural engineering department at Iowa State College, leaves this country August 23 to take up work as an instructor in agricultural engineering at the Allahabad Agricultural Institute, Allahabad, U. P., India. He will be associated with *Mason Vaugh,* who has been in charge of agricultural engineering work at the Allahabad Institute for several years.

Necrology

RAYMOND R. DRAKE, associate agricultural engineer, U. S. Soil Conservation Service, stationed at Hastings, Nebr., passed away at his home there on July 19. For some time previous to his passing his work had been that of project supervisor of the Central Great Plains Experimental Watershed. He was born at Ravanna, Mo., November 11, 1899, and grew up on a farm in Kansas. He graduated from Kansas State College in 1929, immediately started his work with the U. S. Department of Agriculture, as a junior agricultural engineer, on the Guthrie, Okla., project, and was later in charge of the soil erosion experimental farm at Hays, Kans. He had been a member of the A.S.A.E. since 1930. Several of his papers presented before meetings of the Soil and Water Conservation Division were published in AGRICULTURAL ENGINEERING. He is survived by his widow, Mrs. Mildred Drake.

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the July issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Harry R. Ball, shipping clerk, International Harvester Co. (Mail) 815½ Vermont St., Quincy, Ill.

Robert S. Barnett, utilization specialist, Central Georgia Membership, Box 33, Jackson, Ga.

David O. Brant, managing owner, Brant Rancho, Canoja Park, Calif.

Craig W. Cannon, Allis-Chalmers Mfg. Co. (Mail) W. 528 N. 32nd St., Milwaukee, Wis.

Clayton E. Gifford, chief engineer, Huber Mfg. Co., Marion, Ohio. (Mail) 591 Summit St.

J. G. Inerarity, technical director, Campo Agro-Pecuario, Box 404, Havana, Cuba.

Ernest J. Kirsch, graduate assistant, Purdue University, Lafayette, Ind. (Mail) 130 Russel St.

Russell E. MacCleery, New England representative, National Highway Users Conference. (Mail) Box 133, Carlisle, Mass.

Raymond B. Mitchell, research associate, Georgia Farm House Investigations. (Mail) 205 University Dr., Athens, Ga.

J. F. Schaffhausen, senior agricultural engineer, Johns Manville Corp. (Mail) 110 Buena Vista Dr., Dobbs Ferry, N. Y.

W. M. Shepherd, director of rural development, Arkansas Power & Light Co. (Mail) 1834 Laurel St., Pine Bluff, Ark.

W. C. Wheeler, instructor, Georgia Vocational & Trades School, Walker Park, Ga.

Richard L. Witz, assistant, agricultural engineering department, Purdue University, Lafayette, Ind.

TRANSFER OF GRADE

O. J. Trenary, assistant professor, agricultural engineering department, Washington State College, Pullman, Wash. (Mail) 410 Campus Ave. (Associate to Member)

Agricultural Engineering Digest

A review of current literature by R. W. TRULLINGER, assistant chief, Office of Experiment Stations, U. S. Department of Agriculture. Copies of publications reviewed may be procured only from the publishers thereof, whose names and addresses may be obtained on request to AGRICULTURAL ENGINEERING, St. Joseph, Michigan

SPRINKLER IRRIGATION IN THE HUMID SECTIONS OF OREGON, *F. E. Price.* (Oreg. Expt. Sta.) C. R. E. A. News Letter [Chicago], No. 17 (1938), pp. 38-40, figs. 3. This paper briefly outlines the development of sprinkler irrigation in western Oregon, pointing out that this method has been practiced for more than 20 yr but has undergone rapid expansion only within the preceding 4 yr. The success of the irrigation in improving the quality of cannery beans to such a degree that canneries made contracts only for irrigated beans, and figures showing large increases in yield and net profit are noted, together with the station sprinkler irrigation experiment on pastures, the nature and cost of the installation, the profit from gain in butterfat production, and the resulting adoption of the practice by dairymen. An improvement introduced since 1933 consists in the use of portable galvanized pipe made in 20-ft sections with special rubber gaskets and quick couplers instead of permanent laterals and rubber hose. The portable lines can be moved in from 30 to 45 min. The 5-hp 100 gal per minute installations usually have a 4-in main of light-weight steel pipe with flexible couplings to which a 3-in portable lateral is attached at 60-ft intervals. Usually 10 revolving sprinklers covering areas 75-80 ft in diameter are used. Even the main pipe line is easily moved to another field if the pasture is to be rotated with other crops. In most instances, the water is pumped from streams, although there are some shallow-well and deep-well installations.

GENERAL PURPOSE FARM REFRIGERATOR, *P. T. Montfort.* (Tex. A. and M. Col.) C. R. E. A. News Letter [Chicago] No. 17 (1938), pp. 43-45, figs. 2. A side-section drawing, photograph, and bill of materials show, in part, the construction of a refrigerator of 30 cu ft net storage capacity, all materials being those usually available at local lumber and hardware dealers. For simplicity and ease of construction, walls, floor, top, and front sections are built in separate units, then assembled with heavy lag screws. Insulation consists of 5 in of sheet cork laid with asphalt and sealed with a layer of tarred building paper on either side. The outside finish of the walls, top, and bottom are of tongue-and-groove flooring. The inside sheathing is ⅜-in moisture-proof plywood. The door is finished in ⅜-in plyboard on the inner side and ⅝-in plyboard on the front.

A ¼-hp compressor was found to supply refrigeration ample to maintain a box temperature of 36F under normal conditions.

AN ELECTRICALLY HEATED AUTOMATIC WATERING TROUGH, *F. D. Yung.* (Univ. Nebr.) C. R. E. A. News Letter [Chicago] No. 17 (1938), pp. 45-47, fig. 1. The waterer consists of a watering trough attached to the outside of the dairy-barn wall and a tank attached just inside the same wall, equipped with a float and float valve, containing the electric water-heating unit, interconnected through the wall with the trough by two short lengths of 2-in pipe. The electric water-heating unit consists of 60 ft of soil-heating cable having a power requirement of approximately 400 watts. The soil-heating cable is coiled in the bottom of one end of the inside tank. As the warm water rises from the heating unit it flows through the nearest interconnecting pipe into the outside trough, returning through the other pipe to the inside tank. A central baffle in the tank helps direct the flow of water. The water temperature in the inside tank is controlled by a bulb and bellows-type thermostat adjusted to close the heating circuit at 70F and to open it at 76.5F.

From January 19 to March 24, 1937, a total of 12,561 gal of water were used by from 18 to 22 milk cows. The electric energy consumption was approximately 0.05 kw-hr per gallon of water heated or 0.5 kw-hr per cow per day.

SOIL INVESTIGATIONS AT THE MISSOURI STATION, Missouri Sta. Bul. 413 (1940), pp. 89-97, figs. 2. Crop rotation and fertilizer experiments, systems of soil management for the most important soil types in Missouri—soil experiment fields, and the mapping of Missouri soil types—soil survey, are briefly reported upon by M. F. Miller and H. H. Krusekopf; land classification of Missouri, by Krusekopf; the fineness of grinding limestone, by W. A. Albrecht; the calcium content of soils and its relation to acidity and the response of soils to liming, by Albrecht and E. R. Graham; mechanical analysis of colloidal clays, by C. E. Marshall; the colloidal nature of soil organic matter, by L. D. Baver and N. S. Hall; the nature of soil structure and its influence upon soil tillage, by Baver; the nitrogen and carbon in soils under different systems of soil treatment and management, by Miller and Albrecht; the utilization of cornstalks and straw in soil building, by Albrecht and J. C. Wooley; effects of different soil treatments, long continued, upon bacterial activity in the soil, by Albrecht and B. R. Browning; the improvement of permanent pastures, by Miller and Krusekopf; and increasing the productivity of Missouri pastures, by Baver and J. B. Page.

Soil erosion and runoff are discussed by Miller, Krusekopf, Baver, and J. H. Neal; and effect of rainfall impact on soil erosion, by Baver and Neal.

HOMEMADE RUBBER TIRED CARTS AND TRAILERS, *H. H. DeLong.* South Dakota Sta. Bul. 333 (1940), pp. 31, figs. 21. Used car wheels, axles, frames, and second-hand tires and tubes were used with good results. Draft tests, including measurements of starting force and pull at various points during a run of 107 sec with an average acceleration of about 0.05 ft per second, indicated that the pneumatic tire rolls more easily than a steel wheel on all but a very smooth, hard surface; that the large diameter wheel is superior to the small diameter wheel in both the steel wheel and in the pneumatic tired wheel; that a high inflation pressure gives the least rolling resistance with pneumatic tires on hard, smooth tracks; but that a low inflation pressure gives the least rolling resistance with pneumatic tires on soft or rough tracks.

The tires with the larger cross sections have proved more adaptable to farm cart uses than the small cross-section tire, although the large cross-section tire adds greatly to the width of farm carts or seriously reduces cart capacity.

It is further noted that the 6-16 tire is by far the most popular size today, with the result that second-hand casings and tubes in this size tire can be obtained easily and cheaply. The old steel disk automobile wheel can be cut down by a welder and a 6-16 drop-center rim welded on to make a trailer wheel which will use the popular sized tire. The bicycle wheel is desirable only for very light carts which are to carry loads of 150 lb or less per wheel. A trailer for moving brooder houses and farrowing houses can be made of old car parts. Such a trailer lightens the work, saves yards and lanes, and prevents serious twisting of framework which the buildings receive when dragged on skids. The low platform trailer can be equipped with water tank and sack rack for hauling feed and water to hogs on pasture and has numerous uses about the farm.

SOME OBSERVATIONS ON THE BEHAVIOR OF MODELS OF GULLY CONTROL STRUCTURES, *H. B. Roe.* (Minn. Expt. Sta.) Agr. Engin., 19 (1938), No. 8, pp. 359-362, 364, figs. 8. This paper deals with a hydraulic laboratory study, carried out by means of a model, of action of water from heavy runoff on or around the aprons at the foot of dams used in gully control, to determine essential design factors. Gully-floor gradients must be reduced to a stable condition, apron gradients should be steeper than those of the gully floor with a 3-ft cut-off wall at the apron toe, and submergence of apron toe below gully floor is desirable. A table of recommended lengths of aprons for differing conditions is presented. A cross wall 1 ft high, across the apron floor, from 3 to 5 ft from foot of dam, is indicated as essential. Side walls of the dam should be turned at right angles to line of flow and run well into side banks of gully, and heavy riprap, flush with the toe of the apron, and extending from 6 to 8 ft beyond, is essential in heavy flow.

PROBLEMS OF SILAGE, *C. F. Rogers.* (Minn. Expt. Sta.) Natl. Assoc. Silo Mfrs., Ann. Proc., 26 (1938), pp. 93-116; abs. in Minnesota Sta. Rpt. 1939, p. 51. This is a restatement for the information of silo manufacturers of the problems of silage making, the fundamental processes of silage formation being reviewed and related to the silo itself. *(Continued on page 330)*

Agricultural Engineering Digest

(Continued from page 328)

CONSISTENCY AND PHYSICOCHEMICAL DATA OF A LOESS PAMPANEO SOIL.—I, PHYSICOCHEMICAL PROPERTIES OF SAMPLES FROM DIFFERENT DEPTHS OF A PROFILE, *H. F. Winterkorn and G. W. Eckert.* (Mo. Expt. Sta.) Soil Sci. (Baltimore, Md.), 49 (1940), No. 1, pp. 73-82, figs. 5. From data on the mechanical composition, consistency properties, heat of wetting, and sorption of liquids obtained with samples taken from different depths of a profile of loess pampaneo soil, the authors conclude that a large clay content and a large plastic index indicate rather the potential water-holding capacity of a soil than the behavior of the natural soil toward the action of water *in situ.* The actual behavior of a relatively dry soil system toward water can be represented as a dynamic equilibrium between the wetting energy of the water and the cohesive forces acting in the soil system. The mechanism of the water attack is a function of the accessibility of the internal surface of the soil. The amount and type of the organic material in a soil exerts a considerable influence on the behavior of the soil toward water. In this connection, the change of the C : N ratio of the organic material with change in depth of the profile is probably of importance.

From a practical standpoint, soil from the surface 8 in should make a better subgrade for roads than the subsoil. It should also give better results in bituminous stabilization, as indicated by its preferential wetting with benzene.

AGRICULTURAL ENGINEERING INVESTIGATIONS AT THE IOWA STATION, Iowa Sta. (Ames) Rpt. 1939, pt. 1, pp. 47-54. Farm-building losses due to wind and fire are reported upon by H. Giese, most of the study having been devoted to bent, glued, laminated rafter strength tests which showed the wood of rafters made with casein glue and 8 yr in service to fail in horizontal shear before the glue failed; agricultural engineering service, by J. B. Davidson; utilization of clay products in farm-building construction, atmospheric exposure tests of wire and fencing (in which the thinnest of zinc coatings show no evidence of a failure of the protective coating), utilization of plywood in farm-building construction, utilization of steel in farm-building construction, utilization of lumber in farm-building construction, and farm-fence construction, all by Giese; utilization of agricultural wastes for farm-building insulation (tests on the permeability of wall materials to water vapor, on specially built wall sections to avoid moisture condensation within walls, and to determine the most suitable preservatives and the amount necessary to prevent mold growth at various moisture contents), by H. J. Barre; design, development, and trial of a two-way terracing machine, by E. V. Collins; and efficiency and economy of pneumatic tires for transport wheels on agricultural equipment, by E. G. McKibben.

A GUIDE FOR MEMBERS OF REA COOPERATIVES, U. S. Dept. Agr., Rural Electrif. Admin., 1939, pp. 48, figs. 33. This booklet consists mainly of questions likely to occur to the members or prospective members of Rural Electrification Administration cooperative groups, with answers to these questions. It contains an introductory message from the Secretary of Agriculture and concludes with a statement of the Rural Electrification Act of 1936.

THE IMPROVED FOOL-PROOF POULTRY HOUSE, Missouri Poultry Sta. (Columbia) Bul. 40 (1939), pp. 33, pls. 2, figs. 18. This bulletin discusses size and shape, pointing out that the square floor plan provides a given floor space at the least cost for materials and with the least exposed wall surface; height, which is considered to be best made 8 ft at the front and 6 ft at the back, with plain shed roof; the foundation, which should be of concrete, deep enough to be rat and frostproof, the recommended dimensions being 6-in thickness and from 12 to 15-in depth, with from 8 to 12 in above ground outside at the low point; floors (for which plans are not included, though floor construction, especially of concrete, is fully discussed and illustrated by photographs), the dirt floor being considered unsatisfactory if either wood or concrete is possible, the wood floor very satisfactory though less durable than concrete, and the concrete floor best if properly made; construction of a concrete foundation and floor; walls, for which shiplap or drop siding are recommended, or ordinary box lumber if cracks are battened after settling and shrinking; shape and type of roof, the semimonitor and monitor types being condemned as expensive, difficult, and likely to give too much air space in most climates; windows and sunshine; ventilators, front and rear; doors; roosts; droppings platform and ceiling; arrangement of nests; trap nests; home-made trap nests; dry-mash hopper; feed bins; partitions; exits; arrangement of interior; etc. Side and end plans and elevations are included.

REPORT OF THE MECHANICAL ENGINEERING AND IRRIGATION INVESTIGATION SECTIONS, COLORADO STATION. (Coop. U.S.D.A.) Colorado Sta. (Fort Collins) Rpt. 1939, pp. 22, 23, 37-41. Development of a "single seed ball" planter giving 22 per cent more singles than were obtained with a standard commercial planter, trials of a disk furrow opener which resulted in distinctly greater initial germination than was obtained by means of a shoe furrow opener, the design of a multiple disk press wheel which gave significantly greater initial germination stands than standard commercial press wheels produced, and progress in the replacement of thinning with a long-handled hoe by a mechanical tool method are briefly noted.

In the irrigation work there are noted, under the head of design and invention of apparatus, work on an adjustable tube orifice meter, an integrating instrument, a vortex tube sand trap, a riffle deflector-vortex tube sand trap, a siphon type of sand trap, farm lateral lining, the Parshall measuring flume, current meters, and an hydraulic laboratory. Snow survey and irrigation forecasts and pumping for irrigation are also briefly discussed.

TRACTOR REPAIR AND MAINTENANCE, *R. I. Shawl.* Illinois Sta. (Urbana) Cir. 499 (1939), pp. 58+[2], figs. 31. This circular describes the various parts of a tractor that need attention from time to time, tells what to look for in checking to see that the parts are in proper working order, and gives detailed directions for adjustment and repair. A complete check list showing what to do and when to do it is provided. The qualities of tractor fuels, oils, and other supplies, and their suitability for use under different operating conditions, are also discussed. A short list of the operations which should be left to the expert motor mechanic is given before directions for any of the work here taken up.

THE AGRICULTURAL SITUATION IN SAN FERNANDO VALLEY, CALIFORNIA, *P. A. Ewing.* U. S. Dept. Agr., Bur. Agr. Engin., 1939, pp. [4]+128, figs. 15. This is a report of a survey by the Division of Irrigation of the Bureau of Agricultural Engineering of the conditions affecting agriculture in San Fernando Valley, Los Angeles County, as in the autumn of 1938, including the costs of crop production, with special reference to the cost of water necessary for irrigation.

MULCHING TO ESTABLISH VEGETATION ON ERODED AREAS OF THE SOUTHEAST, *S. Franklin.* U. S. Dept. Agr. Leaflet 190 (1939), pp. 8, figs. 6. Green pine branches have proved to be the most successful mulch. The branches should be cut about 3 or 4 ft long and always laid with the butts in the direction of the immediate runoff. The ends of the pine needles are in this way held close to the ground in the best position to catch silt. Grain straw and pine litter as mulch provide good protection for germination and early plant growth, but they do not furnish shade later for the young plants as the pine brush does. Cane begasse also is satisfactory as a mulch if it has weathered a year before it is used. An acid in freshly pressed cane bagasse seems to be toxic to newly sprouted seedlings. Another good mulch material consists of *Lespedeza sericea* stems. In some instances the stems from which the seed have been flailed are used as mulch. Enough seed often remains attached to the stems to give satisfactory stands, but this cannot be relied upon as a general practice. When unthreshed *L. sericea* is used as mulch, satisfactory stands are obtained almost without fail. Premulching (application of a mulch well in advance of seeding) was found advisable in some situations. The use of annuals for temporary ground cover, mulch, and protection for the perennial plant was effective for eroded field borders and other galled strips which could be prepared with farm machinery. It is noted that for this use the plant chosen must be capable of free growth on poor sites, must produce a considerable bulk of stalk and leaves, and must not reseed readily. Only browntop millet, Sudan grass, and common sorghum have thus far met these requirements.

PROTECTING FIELD BORDERS, *V. E. Davison.* U. S. Dept. Agr. Leaflet 188 (1939), pp. 8, figs. 6. Erosion of field borders is greatly accelerated by lack of cover and in many cases by the accumulation of water from the ends of furrows. The border can be made useful, and the woods kept from encroaching on the field, by the use of vegetation controlling erosion and converting the unsightly strip into a border of annual or perennial herbaceous plants for use as a turnrow. It can be made a good place to encourage some of the farm wildlife such as rabbits and quail and other familiar birds. This leaflet explains how farmers may protect their field borders and at the same time encourage an increase of desirable wild animals on the farm. A field border, properly prepared, should provide a strip on which woodland encroachment is prevented; a vegetated drain, where needed, to carry off excess water from the ends of furrows; a turnrow for work animals and equipment; and as much food, cover, and nesting protection as possible for wildlife. *(Continued on page 332)*

Attractive concrete milking barn and bottling plant of Meadowlark Dairy, Pleasanton, Alameda County, Calif.

Agricultural Engineering Digest

(Continued from page 330)

Physics Laboratory Aids in the Solution of Soil and Water Conservation Problems, *W. Gardner.* Farm and Home Sci. [Utah Sta.] 1 (1940), No. 1, p. 12, fig. 1. This is a brief popular report of experiments on drainage of waterlogged soils, irrigation erosion, drain-tile spacing, permeability of clays with reference to their use for lining irrigation ditches, etc.

Mechanical Harvesting of Cotton as Affected by Varietal Characteristics and Other Factors, *H. P. Smith, D. T. Killough, D. L. Jones, and M. H. Byrom.* Texas Sta. (College Station) Bul. 580 (1939), pp. 49, figs. 17. A stripper-type harvester and an extractor, developed by the station, were mounted on a tractor and used to study varietal characteristics influencing machine efficiency and extracting qualities of different varieties. Cleaning qualities were tested with a cylinder cleaner.

Varietal characteristics affecting machine efficiency were found to be shape of plant, height of plant, length of branches, number of branches, density of foliage, type of boll, bolls borne singly or in clusters, storm resistance, degree of boll spread, fluffiness of the cotton, brittleness of branches and boll peduncles, and height of first branches above ground. The best plant type for both the mechanical stripper and the picker is one having relatively short but numerous fruiting branches with short nodes, no vegetative branches, an open-type growth, light foliage, storm resistance, and a large, strong boll on a single peduncle which will snap easily under tension but will withstand considerable plant agitation. Plants at College Station averaging from 30 to 32 in in height gave an average machine efficiency of 92.1 per cent. At Lubbock plants averaging from 20 to 24 in in height gave 98.2 per cent average efficiency. Varieties producing numerous long branches gave lower efficiency than varieties with shorter branches. It was observed that cotton bolls hard to pull from the plant may cause higher percentages of loss with the stripper-type harvester, but bolls that snap off too easily were also found not to be desirable. The general average angle of spread of cotton bolls for all varieties tested was 120 deg at College Station and 115 deg at Lubbock. Plant characteristics appeared to affect machine efficiency more than either mechanical factors or cultural methods.

At College Station hand-picked averaged one-half grade better than hand-snapped and one and one-half grades better than machine-harvested cotton. At Lubbock, in 1937 machine-harvested cotton averaged one grade lower than handsnapped, but in 1938 the average for the three methods of harvesting was strict middling.

Factors found to influence the efficiency of an extractor were rate of feeding and of flow of material through machine; speed of extractor saws; compactness; uniformity of distribution; agitation; amount of burs, unopened bolls, limbs, sticks, and leaves; size of boll; shape of boll; weight of bur; degree of boll spread; fluffiness; storm resistance; fiber drag; and length of staple. Cleaning was influenced by previous handling, quantity and kind of trash, type of cleaner, speed of cleaner parts, kind and condition of screen, rate of feeding, density of fiber on seed, fineness of fiber, length of fiber, and moisture content. Trash was more easily removed from coarse-bodied than from fine, silky cotton. The grade of mechanically harvested cotton was affected by the quantity and kind of trash; weather conditions; time of exposure; fiber injury by harvester, extractor, cleaner, and gin; and fiber characteristics such as fineness, density, and length.

The average acre yield of cotton harvested with the station harvester ranged from about one-half bale at College Station to approximately a bale at Lubbock. The authors find that the harvester will harvest low or high yields equally well if under comparable conditions of plant type and growth.

Use and Abuse of Wood in House Construction, *R. P. A. Johnson and E. M. Davis.* U. S. Dept. Agr., Misc. Pub. 358 (1939), pp. 25, figs. 63. This publication is based upon a recent inspection by the Forest Products Laboratory of 600 houses under construction in 20 communities in northern, southern, and eastern states and deals principally with those construction features that the inspection showed were most likely to be misunderstood or neglected. It concerns carpentry and the application of structural principles, as well as the quality of wood used therein, rather than finish or decoration, arrows, circles, and lettering added to the photographs being used to make the nature of the details respectively considered entirely clear to those without technical knowledge of building methods. Special emphasis is placed on those details of construction which are necessary to provide adequate drainage from all wood members and to prevent penetration of water into spaces in wood construction from which it cannot readily escape, on sill and frame construction to avoid uneven shrinkage and unequal settling, and on effective protection where termites are to be expected. *(Continued on page 334)*

Agricultural Engineering Digest

(Continued from page 332)

MAJOR TEXAS FLOODS OF 1935, *T. Dalrymple et al.* U. S. Geol. Survey, Water-Supply Paper 796-G (1939), pp. V+223-284, pls. 9, figs. 10. A very heavy rainstorm early in the morning of May 31 over the Seco Creek Basin reached a maximum of from 22 to 24 in in 3.5 hr. The resulting flood in Seco Creek exceeded any previously known. A slope-area measurement of discharge made in a reach about 11 mi above D'Hanis gave a peak discharge of 230,000 sec-ft from a drainage area of 153 sq mi, or 1,500 sec-ft per square mile.

Heavy rains, amounting to probably 20 in at some places, fell over the Colorado and Nueces drainage basins the first 2 weeks in June, causing floods greater than ever had been recorded in these basins. The maximum discharge of the West Nueces River at a reach about 28 mi north of Brackettville was 580,000 sec-ft from a drainage area of 402 sq mi, which is equivalent to 1,440 sec-ft per square mile. So far as known this is the highest discharge ever recorded from an area of like size. The greatest recorded discharge on the Nueces River was near Uvalde, below the mouth of the West Nueces, where the peak discharge was determined as 616,000 sec-ft. The drainage area is 1,930 sq mi. The peak stage of 36.9 ft exceeded by 10.5 ft the previous maximum known stage (June 1913).

SAVING SOIL WITH SOD IN THE OHIO VALLEY REGION, *K. Welton.* U. S. Dept. Agr., Farmers' Bul. 1836 (1939), pp. [2]+30, figs. 17. Under good management, grass produces economical feed in pasture and meadow and increases yields on cropland when used in rotations or as a cover for the land when it is not in other crops. The use of grass in increasing the productivity of farm land, in conserving soil on pasture and cropland, and in protecting smaller eroded or erodible areas is discussed. The recommended practices have general application throughout the Ohio River drainage basin and Michigan.

AGRICULTURAL ENGINEERING INVESTIGATIONS AT THE CORNELL STATION, [Ithaca, New York] Cornell Sta. Rpt. 1939, pp. 101, 102. These have included electric farm-fence trials, in which the range of study has narrowed to control by transformers of high magnetic leakage and to the design of suitable transformers, by H. W. Riley and S. Krasik; farm-produce storages and their refrigeration, by E. L. Arnold; and other projects, including farm power machinery, by B. A. Jennings and F. W. Barrett; brooding-equipment tests and design, by Jennings and C. E. Lee; development and test of electric dairy-utensil sterilizers, by Jennings; quick freezing and storage of frozen farm products, by Jennings and W. Ranney; and a study of the design and construction of outdoor steps, garden pools, pergolas, and small dams, as used in landscape design, by A. H. Sayer.

AGRICULTURAL ENGINEERING INVESTIGATIONS AT THE MARYLAND STATION, Maryland Sta. (College Park) Rpt. 1939, pp. 19-21, 29, fig. 1. Work on grain storage on the farm and on electric milk-pasteurizer investigations is noted, together with hydrologic studies with reference to soil moisture conservation, soil fertility, and flood control.

THE STRAW-LOFT POULTRY HOUSE, *H. H. Alp and W. A. Foster.* Illinois Sta. (Urbana) Cir. 501 [1939], folder, pl. 1, fig. 1. This circular is essentially similar to Circular 412 of the same station, of which it is a revision, covering, as before, the construction of a 20x20-ft house and giving plans, bill of materials, etc.

SELECTED ANNOTATED BIBLIOGRAPHY ON SEDIMENTATION AS RELATED TO SOIL CONSERVATION AND FLOOD CONTROL, *C. B. Brown and F. F. Barnes.* U. S. Dept. Agr., Soil Conserv. Serv., 1939, SCS-MP-20, pp. [1]+40. From numerous articles on each of the several aspects of the sedimentation problem, the compilers of this bibliography have selected one or more papers on each of the more important phases of the subject and all papers that cover several phases and are more or less comprehensive. Especially the needs of personnel engaged in flood-control surveys, and the particular problems which they face, have been kept in mind. Each citation is accompanied by a brief abstract.

Literature Received

COMPILATION OF RAINFALL AND RUNOFF FROM THE WATERSHEDS OF THE RED PLAINS CONSERVATION EXPERIMENT STATION, GUTHRIE, OKLAHOMA (1931-38), by J. W. Slosser. Paper bound, mimeographed, 8x10½ in. One of a series on Hydrologic Studies, reporting by stations the data recorded, largely in tables and graphs, with brief descriptive information on the station, watersheds, instrumentation, and methods of compiling data. SCS-TP-32 (June 1940.) *(Continued on page 336)*

Literature Received

(Continued from page 334)

MANUAL OF FARM SHOP PRACTICE, by Mack M. Jones. Paper bound, 92 pages, 6x9¼ in, indexed. Exercises in woodwork, cold metal work, general blacksmithing, toolmaking and tempering, welding, soldering and sheet metal work, harness work, pipe fitting, tool sharpening, and ropework, selected for economy of instructor and student time in the teaching and learning of fundamental shop processes, for economy of materials, and for value of the finished work. Job outlines are specific enough to encourage satisfactory work, but allow for adaptation and for use of judgment and resourcefulness by the student. McGraw-Hill Book Co., 330 West 42nd St., New York, N. Y. $0.75.

EMPLOYMENT BULLETIN

The American Society of Agricultural Engineers conducts an employment service especially for the benefit of its members. Only Society members in good standing may insert notices under "Positions Wanted," or apply for positions under "Positions Open." Both non-members and members seeking to fill positions, for which ASAE members are qualified, are privileged to insert notices under "Positions Open," and to be referred to members listed under "Positions Wanted." Any notice in this bulletin will be inserted once and will thereafter be discontinued, unless additional insertions are requested. There is no charge for notices published in this bulletin. Requests for insertions should be addressed to ASAE, St. Joseph, Michigan.

POSITIONS WANTED

AGRICULTURAL ENGINEER with B.S. and M.S. degree desires position requiring engineering training. Prefers research or teaching, or employment with a farm implement company. Has five years' experience teaching, research, and extension work with college. Six years' experience in soil conservation work with research and operations section of the federal government. Experience in pump irrigation work. Farm background. Age 34. Married. Reference and complete information furnished upon request. PW-321

AGRICULTURAL ENGINEER with B.S. degree from southern college and M.A. degree from midwestern university (1938), desires employment as instructor, with farm implement company, or in agricultural extension. Has five years' teaching experience, one year research, and two years as construction supervisor. Farm background. Age 33. Married. Reference and professional record available upon request. PW-322

AGRICULTURAL IMPLEMENT ENGINEER, graduate of A. & M. College of Texas in 1929, desires employment in the agricultural implement field, preferably something in the nature of a designing foremanship. Has had several years of design experience in most agricultural lines, except tractors and tractor equipment, and is well acquainted with shop practice. PW-323

ENGINEER, with B. S. (M.E.) 1934, desires employment with private concern. County surveyor 1 year, and 4½ years with U. S. Soil Conservation Service as assistant agricultural engineer. Have had additional extension work in civil engineering. Age 29. Married. PW-324

AGRICULTURAL ENGINEER with B.S. degree in agricultural engineering from Kansas State College, and who recently completed requirements for master's degree from the same institution, desires employment in the field of rural electrification or farm power and machinery. In his work for the master's degree, he specialized in milk cooling and refrigeration. Age 25 years. Will go anywhere. PW-325

AGRICULTURAL ENGINEER, graduate of Virginia Polytechnic Institute, desires employment where past experience will be of value in future work. Has farm background and three years' experience as an assistant county agent in soil conservation and engineer in charge of a large terracing unit. Has had considerable experience in contacting and working with farmers. Past experience mainly with extension division work, machinery, and erosion control practices. Can furnish best of references. Age 25. Single. PW-326

AGRICULTURAL ENGINEER, 1939 graduate with bachelor's degree and farm background. Have had experience in public speaking and experience with the S.C.S. Am especially interested in demonstration and advertising work where public speaking is required, but will consider position in any field of agricultural engineering. Age 26. Single. Health excellent, no defects. References furnished. PW-327

AGRICULTURAL IMPLEMENT BLOCKMAN, with three years in agricultural engineering work at Kansas State College and ten years' experience with large manufacturer of farm equipment desires position with another similar concern, or in any branch of agricultural engineering, farm management, or agricultural bank. Age 36. Health excellent. No defects or bad habits. Married. Rural background. Complete credentials furnished upon request. Best of references. PW-328